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USE OF THE LAND IN BRITAIN

SINCE the appearance in 1944 of the White Paper on the utilization of land issued by the Coalition Government, it has been fairly certain that any proposals for a central planning authority and for dealing with the difficult problems of compensation and betterment advanced by the Government of the day would be controversial. Of the Planning Bill introduced by Mr. Silkin, it must be said that while it goes a long way towards establishing a workable system planning the use of the land and meeting the fundamental requirements, it is not unreasonably controversial. Dispute as to the price the community should pay for extinguishing the development rights of private owners of land does not alter the plain fact that the extinction of those rights removes the largest single impediment to planning of the use of land on national lines. Moreover, the decision not to transfer to national ownership all land about to be developed, as was recommended by the Uthwatt Committee, and to levy a betterment charge only when a change of land use occurs, in place of a levy on all increments of site value, may add indirectly to the cost of good planning but should not seriously hamper it. The planning sections of the Bill appear to concede virtually all that planners and local authorities have demanded for a generation, and the wide extension of Exchequer grants to local authorities should banish the last remaining fear of local authorities that the policy of systematic urban dispersal, extension of open space in central areas, and the conversion of land to more socially valuable uses, although less remunerative financially, will involve them in financial losses and compensation charges which they cannot face.

Amid the mass of detail with which we are not appropriately concerned here, there are at least two points which claim attention. The first of these concerns the basis of planning. Development without prior permission is in future prohibited, even when a local planning authority is to be responsible for development. Every local planning authority must first survey the area and prepare a development plan indicating the manner in which it proposes that land in that area should be used, and the stages by which any such development is to be carried out. The planning process is to be flexible, dynamic and positive, and doubts as to the adequacy of the unified control proposed were largely—but not entirely—resolved by Mr. Silkin's declaration, in moving the second reading of the Bill, of his intention to use fairly freely his power to create joint planning boards from the one hundred and forty-six counties and county boroughs which are to be the main and primary planning instruments.

These authorities are given three years in which to prepare their broad development plans. Such plans are to show which towns and villages are suitable for expansion, and which can best be kept to their present size; the direction in which a city will expand; the area to be preserved as an agricultural green belt and the area to be allotted to industry and

to housing. In filling in the detail over smaller areas, when development is about to take place, much of the work of enforcement and detailed control will be delegated to the smaller authorities. The central authority will knit development plans into regional and national patterns and will participate in all stages of planning, and local authorities must reconsider their plans at least once in every five years.

While, however, the local authorities are given the legal powers to march with their new responsibilities, as well as the financial resources, there can be no question as to the strain which will be imposed upon many of them, and the first question that arises is the provision of adequate trained staff to discharge the new planning functions and responsibilities. It was stated in the debate that local authorities already need 1,800 more men with technical architectural knowledge than they can get—a figure equal to the total membership of the Town Planning Institute, including students. This is a fresh demand on trained man-power which cannot be ignored, even if in some areas a great deal has already been done to provide the basic surveys required. It will be essential for the local and regional planning authorities to make the fullest possible use of such local surveys by voluntary bodies and to foster further surveys by such bodies as Nuffield College, the West Midland Group on Post-War Reconstruction and Planning, the Northern Industrial Group, and local universities.

The three years in which the local authorities have to prepare development schemes will clearly be too short, even if no difficulty were likely to be experienced in recruiting the additional planning staff and in training that staff in a new tradition which will equip them to understand and to mould the social and economic fabric of the nation, unless the fullest possible help and co-operation is secured from the many who are willing to give it. Mr. Silkin himself recognized the need for associating the universities in particular, not merely with the training of the new type of planner required to carry out this broader conception of planning, but also with research into the economic and social problems of their surrounding areas, as has been done earlier by the Board of Trade. Due regard must, of course, be had to the proper limits of academic studies; but even so, this may be much the most important contribution that the universities can make in the immediate future to the planning of Britain, apart from their continuing function of supplying the nation with men and women trained to take balanced views and imaginatively alive to the human no less than to the technical issues in the problems with which they are called upon to deal.

We can scarcely expect the universities to make an immediate contribution to the supply of the large numbers of new town-planners who will be required, for the University of Durham alone provides a degree course in town and country planning. Indeed, not many of them are likely to be university graduates. Nevertheless, as Mr. Silkin rightly said, the co-operation of economists, geographers, sociologists and others will be required, and the universities can do something more to promote that informed and interested public opinion which is an essential condition of good planning, as well as the supply of first-rate administrators to give effect to the plans. The Bill might well have contained more evidence of the Minister's desire for such co-operation. The immense amount of material which the Bill contains is a further reason for affording the ordinary citizen ample opportunity to express his views. There could be no greater mistake than to attempt to curtail public discussion and informed criticism of the many complex issues which are raised.

The importance of such public discussion is enhanced by a second feature of the Bill which should be noted by scientific workers because of its implications for them. Comprehensive as are its planning provisions, and thoroughly as they remove the main obstacles to the rational and orderly development of the land of Britain—the compensation bogey, the lack of finance for local authorities, the absence of powers of State planning and development—there is one serious omission. Land held by Government departments, except when leased to private persons, will escape all local planning control, and the Minister himself has no authority over the use of land by other Government departments or by statutory undertakings, and no control over the location of industry. There is no provision for harmonizing the planning activities of the many Government departments which will retain power to acquire land, or to reconcile differences regarding the use of land between the Ministry responsible for planning and such departments; and inasmuch as the control of the location of industry is by the Bill itself to be vested in the Board of Trade, the influence of the Board on the planning and development of the community may be as great as that of the Ministry of Planning itself.

How serious is such a position has been well brought out in the recent inquiry into the proposal to dam Ennerdale Water, and in the current debate regarding the acquisition by the Services of land for training areas. The Standing Committee on National Parks, which represents the Councils for the Preservation of Rural England and Wales and the Friends of the Lake District, in a statement on the order concerning Ennerdale Water, which comes inside the Lake District national park, has indicated the perfunctory treatment which public issues may receive at the hands of a department, and the way in which the technical factors may be disregarded. The fate of Ennerdale at the hands of the Minister of Health indicates how slender are the prospects for national parks anywhere if the Ministry of Town and Country Planning remains merely one among several departments with no overriding powers.

The same point is made in a statement on Services training areas which has since been issued by the Standing Committee on National Parks. While the statement is chiefly concerned to direct attention to the necessity for protecting potential national park areas from any form of development inconsistent with their ultimate use when the necessary legislation is secured, it is of interest here as indicating the limitations of the method of handling the claims of

the Services piecemeal before the Inter-Departmental Committee. That Committee can do no more than consider each case in isolation as it comes before it, and report to a committee of the Cabinet on unresolved claims. There is no provision for the consideration of the claims as a whole, still less of the possibilities of co-ordinating and combining claims of different Services and commands and establishing principles by which individual cases can be decided; nor, more important still, for examining the allocation of the total land resources of the country to agriculture, industry, military training, electric power and water supply and popular enjoyment. If that is too large a question to be entrusted to an individual Ministry such as that of Town and Country Planning, it might well be examined by a Select Committee of both Houses of Parliament, as the National Parks Committee recommends. The imperative need for some such body with powers to enforce decisions even on recalcitrant Government departments could scarcely be better illustrated than by the decision of the War Office to retain 238 acres of London's 'green belt' near Coulsdon and Purley for a bombing range. The most perfunctory study of the Land Utilization Survey's map of Great Britain, or of the admirable population maps published for the Ministry of Town and Country Planning, should convince anyone of the need for reconsideration of such proposals.

One of the biggest questions is, in fact, whether the Bill as at present drafted provides machinery of national planning powerful enough to withstand an interested department. The decision should clearly not rest, for example, on whether the capacity of the War Office for passive resistance is stronger than the political importance of London local authorities; it should depend on an unbiased consideration of the best use of the nation's land, and proper safeguards to that end should be provided. It is disturbing to note that Mr. H. D. Hughes's specific question on this point in the debate in the House of Commons on the second reading of the Bill was unanswered when the Chancellor of the Exchequer wound up for the Government.

The incorporation of such over-riding and co-ordinating powers would, however, enhance the importance of the factor on which the efficacy of the whole Act will finally depend—the wisdom with which the control embodied in the Act is exercised. It was well said in the debate, by Mr. J. H. Hare, that the success or failure of the Bill, as it stands, must depend very largely on the wisdom, the integrity and the intelligence of those who are required to administer it. That is the point of most vital interest to the individual citizen, and the answer depends primarily on the quality of the administrator to whom the exercise of the new powers is entrusted. This is an issue transcending all party divisions. Agreed decisions on the financial provisions and on other procedure will not enable the Act to achieve its purposes unless it is administered with wisdom, dispatch and restraint. Indeed, one important reason for welcoming and fostering co-operation in the preparation of schemes contemplated in the Bill is that it should also assist in the training of administrators for that work, and in embuing them with the imaginative insight and understanding of the needs of the public, its comfort and convenience, which it should be the first object of public administration to study and to serve.

MECHANISM OF COLOUR VISION

Retinal Structure and Colour Vision

A Restatement and an Hypothesis. By Dr. E. N. Willmer. Pp. xii + 231 + 4 plates. (Cambridge: At the University Press, 1946.) 21*s*. net.

THE organ of sight continues to challenge imagination and experimental initiative and so maintains its position as one of the most fascinating living structures in existence, and at the same time the source of so much of our most important knowledge about life and matter. The list of British men of science who have made notable contributions to this field is as impressive as that of any other country. It begins with Newton, whose ideas inspired Thomas Young (according to the latter's own words). Brewster, Maxwell, Dalton, Lord Rayleigh made discoveries which are classical. From our own period one need but mention Adrian's brilliant pioneer work on optic nerve impulses, Lythgoe's discovery of transient orange, Stiles' of the directional sensitivity of the retina, and Wright's analysis of the fundamental trichromatic response curves to realize that the tradition is being maintained.

The latest contribution comes from a Cambridge histologist, Dr. E. N. Willmer. It is right that histologists should add their word to the discussion, since physiology has now reached the point at which further advance in our knowledge about the function of the retina must contain new histological terms. There are the well-known receptors, the rods and the cones, which have long been on the stage, probably too long, when one considers that to the receptors is attached a true nervous centre, exceedingly complex, and certainly of fundamental importance for the interpretation of the world around us in terms of brightness discrimination, general light perception and colour. Nature's idea, to project a piece of the central nervous system on to the periphery and thus make it easily accessible to adequate, localized and controllable stimulation, is a hint meant to be taken.

Dr. Willmer approaches his theme in an unorthodox manner. He does not accept the idea, implicit in so much of modern psychophysical work in this field, that there are three kinds of cones, for the perception of red, green and blue colours. He thinks that the cones only are responsible for the long wave-lengths, whereas the green and the blue regions are transmitted by two kinds of rods. In the human fovea there is only the 'green' kind of rod, a day-rod, to which he attributes a sensitivity curve corresponding to the scotopic luminosity curve. This necessitates the further assumption that the 'green' day-rod contains visual purple in some less-adaptable or less-spurious form, since our scotopic luminosity curve is certainly determined by the photochemical properties of visual purple. The choice of ordinates for the response of the cone (the red receptor) has given him greater difficulties owing to the accumulation of physiological evidence on this point which he has felt bound to

observe. He then proceeds to construct a colour chart with his rod- and cone-response curves, compares it with the C.I.E. chart and several other properties of colour vision: altogether a very ingenious, stimulating and, besides, entertaining account of what the mechanism would look like if it had the fundamental response curves which he attributes to it.

Unorthodoxy in this matter, if it is to serve any purpose, can only be of interest if the theory propounded is properly worked out so that one can perceive its merits, deficiencies and value as a stimulus. From this point of view Dr. Willmer's work deserves high praise. In assessing its value as a truthful account of the mechanism of colour vision one must examine separately its two fundamental propositions. The first states that the green and blue regions of the spectrum are perceived by rods. There is a great deal of electrophysiological evidence in favour of this view to which I would like to subscribe myself, in the form that there certainly is a very intimate connexion between rods and colour reception in the short wavelengths. There is also evidence for a great range of variation in the adaptability of the rods, day-rods and properly dark-adapting rods, the latter utilizing the full visual purple sensitivity. Conversely, an intimate connexion exists between cones and red-sensitivity. Willmer's second fundamental assumption consists in ascribing to the day-rods the visual purple distribution of sensitivity. For this view there is no evidence; in fact, such evidence as exists rather suggests that part of the visual purple under the influence of illumination splits into blue and green elementary colour bands with maxima to either side of its own maximum in 500 mμ. In animals, single fibres can be found which respond in this manner. The pure cone eye of the snake has its maximum green sensitivity around 520–530 mμ. The electrophysiological work on single fibres in animals gives a more detailed picture of the retinal mechanism of colour reception than work on man, in fact, several narrow bands; but the spectral loci of the integrated colour bands responsible for red, green and blue reception are in essential agreement with the loci of the fundamental response curves which Wright and his collaborators have been forced to accept as the most probable ones (see, for example, W. D. Wright, "Researches on Normal and Defective Colour Vision, Kimpton, London, 1946). The latter, of course, are averages.

Of Dr. Willmer's two assumptions the first one, therefore, seems to me of greater interest and destined to survive as a starting point for experimentation. Psychophysical work on vision and, in particular, on colour vision tends to be conservative in methods and problems. It scarcely ever aims at an understanding of retinal processes going beyond the simple scheme of response curves attributed to three types of cones. Dr. Willmer is performing a real service to his subject by demonstrating the need for taking up points of view which arise from a consideration of the histological structure of the retina and the physiological experiments directed towards interpreting it in functional terms. He is, for example, rightly concerned with the very fundamental problem as to what use the retina makes of its mechanisms of inhibition, what it signifies that in certain circumstances light does not elicit impulses at all but, on the contrary, stops them. If Dr. Willmer, in pursuing his subject, would turn his gifts of imagination and perseverance into experimental channels he would, no doubt, be able to suggest several interesting ways of studying rods and cones in relation to that little nervous centre placed at the end of the optic nerve just behind the layer of receptors. In view of a few very interesting experiments, found in his stimulating book, this would seem to be a safe forecast.

RAGNAR GRANIT

FROM AQUINAS TO EINSTEIN

Space and Spirit

Theories of the Universe and the Arguments for the Existence of God. By Sir Edmund Whittaker. Pp. vii + 150. (London and Edinburgh: Thomas Nelson and Sons, Ltd., 1946.) 6s. net.

SIR EDMUND WHITTAKER here gives the substance of his Donnellan Lectures delivered in June 1946 in Trinity College, Dublin; and the closing words of the book express its aim, namely, to indicate "that the deeper understanding of the nature of the material universe, which has been achieved by scientific discovery, has opened up new prospects and possibilities to the advocate of belief in God".

Sir Edmund holds that the line of descent of the modern physicist is from the Schoolmen of the twelfth and thirteenth centuries who translated into Latin the Arabic versions of Greek mathematics and science, and were Aristotelians, attaching meaning and value to the concrete things of sense and relying upon experience. Herein they were innovators and modernists, rejecting the Neoplatonist philosophy, dominant since Augustine, for which the material world of sense was the lowest and vilest element in the scheme of things. Aquinas' famous five proofs of the existence of God have their starting point in experience and are grounded in Nature.

Radical changes in physical theory have taken place since Aquinas elaborated his arguments, changes associated with the names of Copernicus, Kepler, Galileo, Descartes and Newton. Then in their turn the classical physical theories of Newton have been subjected to radical criticism and modification in view of the principles of relativity and of quantum-mechanics. Thus one might expect to find little that is relevant to-day in the Schoolmen's reasonings.

In one respect indeed their attitude differed from that which has been general since the Renaissance; they strove to understand the purpose behind events rather than to discover the laws of their operation. Yet the real difference is not so great as might appear, since to regard natural objects as striving to accomplish some purpose is only a naïve way of saying that their behaviour is not haphazard or lawless. Either formulation of the initial assumption would serve the purpose of Aquinas' argument. Indeed, it is in some respects reinforced by recent developments. For example, the ability of the mathematician to predict the existence of wholly new and unexpected phenomena in the external world reveals an order in Nature which transcends the range of experimental facts. Einstein's predictions of the bending of light-rays by the sun's attraction is a case in point. Again, recent researches have led to the conclusion that the universe cannot have existed for an infinite time in the past, at any rate under the laws of Nature as we know them. This re-introduces the idea of a creation, established by rational science,

and not, as held to be the only possible way by Aquinas, by revelation. Moreover, the fact, unknown to Aquinas, that the *same* mathematical laws are valid over the cosmos, leads to the inference that there is only a *single* mind involved in the whole creation. In short, "the proof from Order is to-day more complete, more comprehensive, and more majestic than in the form in which it was presented in the thirteenth century".

Those who are interested in the bearing of modern physical theories upon ultimate problems will highly value this lucid and original book.

J. C. HARDWICK

ORIGINS OF WATER TRANSPORT

Water Transport

Origins and Early Evolution. By James Hornell. Pp. xv + 307 + 45 plates. (Cambridge: At the University Press, 1946.) 30*s*. net.

MR. HORNELL has accomplished a valuable work in preparing this account of how mankind conceived and made use of floating structures in order to traverse stretches of water. His research is confined to the evolutionary period down to the sailing ship; details of construction are reviewed and distribution in time and space recorded.

Relatively little is known of man's greatest achievements; his written history is but the history of yesterday, and the most significant advances—such as the development of speech—were prehistoric. If the source of European civilization can rightly be traced to certain amphibious tribes who dwelt on the coast of the Mediterranean, raising the piles of their houses in the water so to escape the greater perils of the land, then some kind of rudimentary navigation was the prime condition of human progress, and the importance of that development is transcendental. Mr. Hornell deals with primitive watercraft in three main groups: (*a*) floats, rafts and kindred craft; (*b*) skin boats: coracles, curraghs, kayaks and their kin; (*c*) bark canoes, dugouts and plank-built craft. Groups (*a*) and (*b*) have each five chapters covering the evolution; group (*c*) carries nine chapters and reflects to some extent the background of human aspiration—social, religious and economic—which was the cause of the technical development. Here the genetic relation of the bark canoe to dugouts and plank-built boats is considered, and the author, while re-stating his conviction that the boats of dinker and carvel build in use in Europe to-day are derived ultimately from the dugout canoe, observes that the genesis of many current types of dugout was the imitation in wood of the form of a canoe made from a sheet of bark. This implies that the origin of actual boat construction must be moved back much further in time, because the ancient forest people—regarded as the first 'human' ancestors—were restricted to the rudest of stone tools and yet, it is inferred, were capable of stripping the bark from trees, and by the use of a long strip curled up at each side, with the ends stopped by clay, were able to navigate the waters. The hypothesis derives support from the material culture of the Australian aborigines to-day, which can be little if at all advanced beyond that of our ancestral forest dwellers, and among whom all the relevant gradations in canoe design have been found. The possibility that dugouts evolved independently in some localities cannot be excluded, and, as the author remarks, the genetic relationship will probably remain an open question for all time.

Transition from the dugout to the carvel-built ship is more easily determined. The fashioning of the former was primarily a matter of patient labour, even when fire was used, but where large timber was available, the dugout might assume sea-going proportions. Increase in the freeboard of dugouts by the addition of a washstrake certainly marked the first stage, and in certain types the strakes—in the form of rows of superimposed planking—were sewn edge to edge and a strengthening frame was inserted. Bending of the sides outwards to obtain greater beam; insertion of wedged cross-bars to preserve the flare, and its continuation by a deep washstrake; and, finally, reduction of the underbody to the form of a keel member were further stages.

The historic differentiation between the techniques of carvel and clinker build is elucidated, and also the Mediterranean origin of the former. It is significant that all boats there and in the Indian Ocean are so built, whereas the clinker build is found only in the seas of north Europe. The determining of prototypes is here obscure: that the latter should have derived from a raft with built-up sides seems credible; but rafts were not used in the bleak northern seas, and we must look to the dugout canoe as the precursor of clinker build, the essentials of which have persisted since Viking times.

In the final chapter, primitive belief in the need for intimate association between a protective god and watercraft is discussed—in particular, the prow of the ship as the sanctuary of its tutelary deity. This superstition takes the form of definite and often periodic worship, with suitable offerings, of a protective deity there located, and of traditional acts performed to ensure immunity from the effects of the evil eye—possibly the source of the Christian practice of blessing aeroplanes and other vehicles. Mr. Hornell observes that the rites are often intermingled and cannot therefore be considered separately; most of the instances he cites come within his own personal knowledge. Dedication, with elaborate ceremonies, of a vessel to a goddess who would abide in it, and be its protectress during voyage across the sea, is described; the final rite consisted of the incision of an eye on each bow—the ceremony of the 'opening of the eyes'. This 'cult of the oculus' is still widespread; originally it symbolized the deity's eyes watching for danger, but became debased to a mere amulet. The sacrificial ceremonies connected with launching, and the various rites associated with placating a deity when becalmed, are discussed from abundant data at the author's command. Out of this inquiry little emerges that is satisfying to the technical reader, but the association of the stemhead with such rites is interesting.

It is true, as the publishers say, that the book could not have been written without first-hand knowledge; and in this the author's qualifications are exceptional, for he has travelled all over the world and examined most of the craft he describes and observed their daily use. His investigation was thus carried out in a scientific manner; and when to this scholarship is added, the result cannot be other than illuminating. The book is profusely illustrated by photographs and text-figures and is extremely well documented. Recent distribution of eight categories of primitive craft is shown on Mercator's projection.

M. J. B. DAVY

Sun, Moon and Stars

Astronomy for Beginners. By Prof. William T. Skilling and Robert S. Richardson. (Whittlesey House Publication.) Pp. viii+274. (New York and London: McGraw-Hill Book Co., Inc., 1946.) 12*s*. 6*d*.

THE authors of this book are well equipped for producing a work that will appeal to young people—and one might add to older people, too, who have little or no scientific background. Prof. Skilling has taught astronomy for many years and Dr. Richardson, at present associated with the Mount Wilson Observatory, has devoted a number of years to research. Five parts deal in turn with "The Moon", "The Sun", "The Sun's Family of Planets", "The Stars", and "Astronomers and Observatories", and the subjects are treated in a manner which requires practically no mathematics, or where such is introduced, it is of the most elementary character. The descriptions are excellent for the readers for whom the book is intended, and are illustrated by ninety-nine diagrams and photographs.

The work has been produced primarily for American readers, but it will probably have a good circulation among British readers as well. For this reason it is suggested that a new edition might contain certain amendments where the text is directed specifically to American readers and may mislead others (pp. 48, 109, 165).

A few other points require attention. The reference to the rising of the full moon in September (p. 37) does not apply for all latitudes; and the old theory about the apparent enlargement of the moon when close to the horizon (p. 42) is no longer held. The corona can now be seen without a total solar eclipse (p. 87). It might be inferred (p. 107) that the tidal theory of the origin of the solar system is generally accepted, but it would be more correct to say that it was generally rejected; and the view that swift meteors are hyperbolic (p. 164) is no longer held. These are very minor blemishes which do not detract from the value of a most readable and informative book.

M. DAVIDSON

Exploring Nature with a Camera

By Ernest G. Neal. Pp. 103+62 plates. (London: Paul Elek (Publishers), Ltd., 1946.) 10*s*. 6*d*. net.

BIRD photography has reached such a pitch of excellence, its devotees are so many and so enthusiastic, that we are apt to forget that the camera is a useful aid in many other branches of field work. In "Exploring Nature with a Camera", Mr. E. G. Neal makes this clear. He deals, it is true, with the photography of birds, but he devotes as much or more space to insect photography, night photography, plant photography and so on. His chapter on night work is illustrated by some good flashlight pictures of badgers near their sett, and we envy him the thrill of taking them. The author says in his preface that "this book is written in the hope that the keen naturalist who has got a camera, especially those of the younger generation, will be encouraged to try it out", and it can be highly recommended as a present for the beginner. Although Mr. Neal says his little volume "is not a technical book on photography", it is full of practical information on the use of the camera (not forgetting his hints on the type of instrument) and how to take pictures of birds, mammals, insects, reptiles, flowers, fungi, etc. Here and there, as if by accident, interesting observations are recorded. Commenting that it is often easier to photograph a portion of an object than the whole, say a few twigs rather than the whole tree, he gives as an instance ice-encased twigs during the great 'crystal thaw' of 1939–40, when trees, bushes and other vegetation were thickly coated with clear ice. Then, as an aside, he remarks, "I was interested to see a wych elm tree with the usual covering of ice, for I knew that the white letter hairstreak butterfly (*Strymon w-album*) laid its eggs every year on the twigs of this particular tree, and that they would now be encased in ice. The following July this species was more common than for many years, so the ice had no appreciable bad effect."

FRANCES PITT

Insects of the Pacific World

By C. H. Curran. (Pacific World Series.) Pp. xvi+317+8 plates. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1945.) 15*s*. net.

THIS book is intended as an elementary guide to the insect life on the numerous islands, large and small, of the Pacific Ocean—"from the Galapagos and Hawaii to New Zealand, Sumatra and Burma, and in the area from Australia to Formosa, Japan and the Aleutians". It is a plain, readable account, taking the insects of each order, family by family. Beginning with the true flies, it passes in descending sequence to the Orthoptera and Apterygota. At the end of the book there are brief chapters on the Arachnida and their allies (by W. J. Gertsch), on insects and disease and, finally, instructions on preserving and collecting insects. For the most part the book deals with its subject in very general terms, and says singularly little about individual Pacific insects. Even the well-known elements in the fauna of Hawaii and New Guinea scarcely receive mention. But, as the author remarks, what chance is there to say much about so many insects of which so little is known. The size of the book, indeed, limits the treatment severely. The text-figures and plates are good and, apart from misspellings on pp. 13, 140 and 141, and an erroneous account of *Cactoblastis* on p. 149, the book will aid the beginner who may visit the vast area under consideration.

A. D. I.

Esquisse d'une histoire de la biologie

Par Jean Rostand. Pp. 258+14 plates. (Paris: Libr. Gallimard, 1945.) 140 francs.

THIS sketch summarizes the history of biology from the middle of the seventeenth century up to the present day, the term biology being used in a restricted sense to include only the fundamental problems of organic life, namely, the genesis of life; the formation of the organism; and the evolution of species. While the overall treatment of the subject is chronological, its detailed development is traced in relation to the men of science responsible for major advances. The following examples, selected from the twenty-three chapter headings, suffice to indicate the scope and treatment: Redi, Leeuwenhoek and the microscope; the experiments of Lazaro Spallanzani; Cuvier and the science of fossils; Charles Darwin and the origin of species; recent advances in biology. Short biographies of the naturalists who have made major contributions to biological thought are included in the chapters dealing with their work. The book concludes with a table setting out the principal dates in the history of biology, a brief bibliography and an index of names cited. It should serve as a valuable introduction to the subject for university students in biology.

ATOMIC ENERGY AND ITS APPLICATIONS*

By Sir JAMES CHADWICK, F.R.S.

THE fission process can be briefly described as follows. A neutron is captured by a nucleus of uranium 235, forming a nucleus of uranium 236 in a highly excited state. This immediately divides into two fragments of roughly equal mass, and at the same time from one to three neutrons are emitted (and also some γ-radiation). The fragments fly apart with considerable speed and, in their passage through matter, their energy of motion is finally transformed into heat. These fragments are, in general, unstable and may pass through a series of transformations, emitting β-particles and γ-radiations, before they reach a stable configuration.

It was immediately recognized that this discovery was of the greatest significance and that it opened up the possibility of a practical utilization of the enormous store of atomic energy. Not only did the fission of uranium release a large amount of energy, but also the emission of more than one new neutron each time that a nucleus suffered fission suggested the possibility that the reaction could be propagated from atom to atom, developing a whole chain of reactions from one single event. Such a chain process developing in a mass of uranium might take place at an ever-increasing rate and might involve so many atoms that there would be an appreciable, and possibly an overwhelming, liberation of energy. In this way it seemed that a new type of combustion of matter might be possible which would give an energy yield a million times greater than that obtainable by the combustion of the same weight of coal or oil.

A chain reaction will not necessarily develop in any piece of fissile material. Certain conditions must be satisfied. In the first place, the amount of fissile material, or the reacting system as a whole, must be of such a size that there is not too great a chance that the neutrons produced in the fission process can escape and so be unable to carry on the chain. Secondly, the system must not contain more than a limited amount of material which absorbs neutrons, for in this way again the neutrons will be prevented from continuing the chain reaction.

If these conditions are satisfied, the chain reaction will develop and 'run away', unless some special device is introduced to control it. Thus we have two general types of chain reaction—the uncontrolled reaction and the controlled reaction.

Uncontrolled Reaction: the Atomic Bomb

If we wish to use atomic energy as an explosive the reaction must be uncontrolled, for the more rapidly it can proceed, the greater will be the amount of energy set free and the explosive effect.

The question of size is critical for an atomic explosion, for a chain reaction cannot develop if the mass of fissile material is too small. This is because the reaction depends on the conservation of the neutrons produced in the fissions. If the piece of material is too small or of an unsuitable shape, too many neutrons will escape before they hit a nucleus and propagate the reaction. The proportion of neutrons which escape can be reduced by increasing the size of the piece, since the production of neutrons is a volume effect and will therefore increase more rapidly with size than the loss of neutrons by escape, which is a surface effect. Thus a certain minimum amount of material is required, called the critical size or amount, before the reaction can develop so fully that an explosion occurs. If the piece of fissile material is less than the critical size it will be quite stable; but as soon as it exceeds this a chain reaction will develop and multiply itself with enormous rapidity. Thus all that is necessary to detonate a bomb of uranium 235 is to bring together two pieces each less than the critical size but which when in contact exceed it.

Suppose we have succeeded in doing this by some means, and that at the same moment we shoot a neutron into the material. This will cause fission of one uranium nucleus and produce, let us say, two fission neutrons which in turn produce four, and so on in successive generations. Since the fission neutrons have speeds of the order of 10^9 cm. per sec., and since they do not have to travel many centimetres before they produce new fissions, the time between successive generations, in which the number of neutrons is doubled, is of the order of 10^{-8} sec. In a millionth of a second, therefore, the number of neutrons will have increased enormously and a considerable fraction of the mass of U235 will have undergone fission. If only 1 kgm. is used up in this way, the amount of energy released will be as much as from 17,000 tons of T.N.T. This amount of energy is so great that the mass will attain a temperature of many million degrees and a pressure of many million atmospheres. The high temperature causes the emission of an enormous amount of heat and light, and the sudden expansion of the hot gases produces the shock wave of the explosion.

As the material expands, the neutrons can escape more easily and the reaction stops. By this time the hot glowing gases may have expanded to a diameter of about a third of a mile.

In addition to the blast wave and the intense heat and light from the hot gases, the atomic bomb emits an enormous radiation of gamma rays and neutrons at the moment of explosion. Further, the products formed by the fission process are intensely radioactive, and the total amount formed in the explosion may correspond in activity to many tons of radium.

Control of the Chain Reaction

In order to use atomic energy for industrial purposes, it is obviously necessary to control the chain reaction so that the energy can be released continuously and at a predetermined rate. It seems at first sight that the control of a reaction which can develop so rapidly and which can liberate such enormous energies must be exceedingly difficult. This is, fortunately, not the case, and in practice the control is remarkably simple, effective and accurate.

Control depends on the regulation of the neutron flux so that at a predetermined level the flux remains constant, only exactly as many neutrons causing fission in one generation as in the previous generation. The extra neutrons which are produced in the fissions are removed and made unavailable for the reaction. The reaction will then proceed at a constant rate. This balance can be achieved either: (1) by allowing the excess neutrons to escape from the system; or (2) by capturing them in some absorbing medium.

* From the Melchett Lecture of the Institute of Fuel delivered on October 8. The full lecture is published in the *Journal of the Institute of Fuel*, Dec. 15, 1946.

It will be convenient at this point to define a quantity called the multiplication or reproduction factor. Let us suppose that in a system containing fissile material there is a certain number, P, of free neutrons present at a given time. Some of these neutrons will initiate fissions and thus directly produce new neutrons, Q in number. The ratio Q/P is called the multiplication factor and denoted by k.

If k is less than 1, no chain reaction can develop. Any stray neutrons may produce a fission, but the chain will die away quickly and the system will be perfectly safe. This corresponds to a system which contains less than the critical amount of fissile material.

If k is greater than 1, as in the example quoted above for the atomic bomb, the number of neutrons will increase rapidly from generation to generation and an explosion will occur.

When k is exactly equal to 1, the reaction will proceed at a constant rate and the flux of neutrons will remain constant. This is the condition which has to be achieved for successful application of the chain reaction to general purposes.

The principle of the control of a chain reactor can be illustrated by a simple example. Let us suppose that we have two masses, A and B, of fissile material, each less than the critical amount but together considerably greater than it, and let us consider what happens as A and B are brought closer together.

When A and B are far apart, the leakage of neutrons will be great and the multiplication factor k will be less than 1. Suppose that at some stage in the approach k becomes equal to 0·99 and that we have in the material a source of neutrons which emits 1 neutron per second. This one neutron will produce k neutrons in the first generation, these k will produce k^2, and so on, so that the total number of neutrons being produced per second will be:

$$1 + k + k^2 + k^3 \ldots = \frac{1}{1-k}$$

if k is less than 1.

Thus when $k = 0{\cdot}99$ there will be 100 neutrons produced per second in the material, and the primary source has been multiplied 100 times. As the two parts are brought closer and closer together the leakage of neutrons diminishes, k becomes correspondingly nearer and nearer to 1, and the neutron intensity can be brought to any desired value.

It is evident, however, that an exceedingly fine adjustment of k will be required to reach a high intensity, so fine as to be impossible as a practical operation.

Let us now suppose that the two parts are close enough to make k slightly greater than 1. A divergent chain reaction will now develop and the neutron intensity will rise rapidly, doubling itself in each successive interval of time T given by the formula

$$T = 0{\cdot}7 \frac{\tau}{k-1},$$

where τ is the average life-time of one generation of neutrons.

Thus by making k slightly greater than 1 we could raise the level of neutron intensity very rapidly and, having reached the level it is desired to have in our reactor, we could now reduce k to 1 so that the desired level would be maintained.

While this adjustment is simple in principle, the possibility of carrying it out depends very much on the value of τ. Now the fission neutrons are emitted with velocities of the order of 10^9 cm. per sec., so that if they were all emitted instantaneously upon fission the value of τ would be of the order of 10^{-8} sec. But in order to allow time for the adjustment of the mechanisms which control the positions of A and B, we need a doubling time T of the order of a second; and this would entail an adjustment of the value of k to less than one hundred-millionth part of its value. Even if this could be achieved, there would always be the danger of a slight temperature change or mechanical disturbance which might cause the neutron intensity to rise at an uncontrollable rate and result in a violent explosion.

If the picture I have given were quite accurate, the control of the chain reaction would evidently be a formidable operation. Fortunately, however, not quite all the neutrons are emitted instantaneously upon fission. Some of the fission products transform after a time with the emission of a β-particle into nuclei which are now unstable and emit neutrons.

We have, therefore, in addition to the prompt neutrons released in the fission process itself some neutrons which are delayed after the fission by the time required for the transformation of the fission fragments. The effect of these delayed neutrons is to increase the average time for neutron generation and, therefore, to reduce the rate at which the chain reaction develops.

The importance of this effect can be shown by a simple calculation.

For the purpose of this calculation we may assume that the delayed neutrons form 1 per cent of the total neutron emission from fission and that the average time of delay is 10 sec. We now arrange the assembly of fissile material so that it is only just above the critical condition, with a multiplication factor k greater than 1 but less than 1·01. This means that the prompt neutrons alone will be insufficient to maintain the chain reaction and each generation of neutrons will have to wait for the delayed neutron emission before a divergent increase in intensity can occur. The neutron intensity will double itself for each interval of time T given by

$$T = 0{\cdot}7 \cdot \frac{1-k_p}{k-1} \quad \tau_D,$$

where k_p is the multiplication factor due to the prompt neutrons alone, and τ_D is the average time between the fission and the emission of the delayed neutrons, that is, 10 sec.

If we put $k = 1{\cdot}005$, then k_p will be about 0·995, and the doubling time is about 7 sec.

Thus, provided the assembly is only a small degree above the critical size, the effect of the delayed neutron emission is to make the reaction grow quite slowly. It will therefore be easy to control the reaction and to hold the level of the reaction and the neutron intensity at any desired level. The adjustment of the neutron leakage may be a simple type of mechanical control which moves a small part of the reactor relative to the main system or which moves reflectors which can reflect back into the system some of the neutrons which would otherwise escape. In this way, the reaction can be controlled smoothly and the level of the reaction can be held very steady; in fact, in some of the so-called 'slow reactors', the level can be held to better than one part in 10,000 over long periods of time.

Fast and Slow Neutron Reactors

The systems I have so far considered are known as fast neutron reactors, because the chain reaction is carried on by the fission neutrons without moderation of their speed except that which inevitably must occur in collisions in the system, whether in the fissile material itself or in parts of the apparatus for assembly, etc., and these neutrons have velocities of the order of 10^9 cm. per sec.

Slow neutrons, however, are much more effective in producing fission both in U235 and in plutonium than are fast neutrons. Thus, if the fission neutrons could be slowed down before reproducing themselves, the chain reaction could be maintained in a smaller amount of fissile material, or even in much less pure material than is required for the fast reactor.

One advantage of the slow neutron reactor is the simplicity of control. Some substances, notably boron and cadmium, absorb slow neutrons very strongly. This fact provides a very ready method of controlling the reaction, by moving rods of these materials in or out of the reactor and so adjusting the multiplication factor by changing the loss of neutrons by absorption rather than by changing the loss by leakage as in the fast reactor. It is obvious that a simple mechanical device will suffice to carry out this control.

A very important advantage offered by the use of slow neutrons is that it is no longer necessary to use pure or nearly pure fissile material in order that the chain reaction should maintain itself. In fact, as is well known, it is possible to use natural uranium, thus avoiding the very expensive and tedious process of separating the isotopes.

In this case, owing to the fact that the 238 isotope captures neutrons without undergoing fission and that this isotope is 139 times as abundant as the fissile 235, the choice of material for slowing down the neutrons is rather limited, for very little additional loss of neutrons can be tolerated. For this reason it has not been found possible to use water as moderator, for hydrogen captures slow neutrons too readily. Heavy water makes a very suitable moderator, for the capture by deuterium is small, and it has been successfully used in the United States and later in Canada. It is, however, too expensive a substance to use for large reactors.

The best material readily available at the present time is carbon, in the form of graphite. This has the advantage of being relatively cheap and abundant, and it can be obtained in a very pure state.

Owing to the inevitable, though small, loss of neutrons by absorption in the graphite, the multiplication factor of a uranium-graphite system is not much greater than 1. The critical size of the reactor is, therefore, rather large, and some tons of uranium and of graphite are required. The construction of a reactor of small power is a straightforward matter, but difficulties arise when large power dissipation is desired, of the order, say, of 100,000 kW., owing to the small latitude in the multiplication factor. The nature of these difficulties will be best illustrated by a brief description of the large reactors, the so-called graphite piles, erected at Hanford, although the primary purpose of these piles was the production of plutonium rather than the generation of power.

Natural Uranium Reactor—the Graphite Pile

For reasons depending on the nuclear properties of uranium, the arrangement which gives the highest multiplication factor is one in which lumps of metallic uranium are disposed at regular intervals throughout a large block of graphite in the form of a lattice. The ideal shape would be spherical, but for practical considerations a rectangular block is used. The optimum size of the uranium lumps and of the lattice spacing can be calculated from the nuclear constants of the materials. This was the arrangement used in the first graphite pile of very low power, but it had to be modified for the plutonium production pile. There were two reasons: first, the uranium has to be cooled in order to remove the heat generated by fission, and it is difficult to concentrate the coolant at small lumps, and second, it was required to remove the uranium without disturbing the assembly of the pile.

The arrangement used in the Hanford piles is, therefore, a rod lattice of cylindrical symmetry, in which short rods or slugs of uranium are loaded in cylindrical channels in the graphite moderator. This entails some reduction in the multiplication factor.

The cooling agent, water in this case, is circulated through pipes around the rods. Since graphite pipes are not practical, on engineering grounds, some other material has to be used, and the choice is limited by the condition that the material must have a small absorption for neutrons. The material chosen was aluminium.

Further, the uranium must be protected from the cooling water, for it is easily oxidized, and even if the slugs were not disintegrated by chemical action, sufficient fission products would enter the cooling water to make operation dangerous. The protective jacket must have a high conductivity in order to transmit heat quickly from the uranium to the water, it must not absorb too many neutrons, and it must not corrode. Aluminium fulfils these conditions fairly well.

The introduction of this auxiliary material in the form of cooling pipes, sheathing, instruments, etc., increases the loss of neutrons by absorption, and it is, therefore, necessary to keep down the loss by leakage to a few per cent. This is not difficult, for the leakage can obviously be made as small as desired by making the reacting system sufficiently large.

The problem of dissipating some 100,000 kW. or so is not difficult provided an ample supply of pure water is available, but it is complicated by factors peculiar to an atomic energy reactor. In its passage through the pile, the water becomes radioactive, so that if the water is to be returned to a river a retention basin must be provided to ensure a delay, during which the induced radioactivity dies down to a safe level. Further, the circulating system must be very reliable, and fast-operating controls must be provided in order to shut down the chain reaction quickly in case of failure of the water supply.

The control is essentially no more difficult than for a small slow reactor, but, of course, the large reactor is potentially much more dangerous. The operating controls, connected with instruments in the pile, which measure the neutron density and thus the power level, can automatically keep the pile operating at a predetermined level. In addition, emergency controls are provided to operate as soon as the power level shows signs of undue increase.

The radiation from a pile operating even at low power is strong enough to be dangerous to human life, and that from a high-power pile reaches a fantastic intensity. The whole of the reacting unit must, therefore, be enclosed in steel and thick walls of

concrete, and it must be possible to load and unload the pile through these shields. Any operation on the pile must be carried out by remote control.

The design and operation of the Hanford piles was thus beset by difficulties, many of them new and peculiar to an atomic energy plant, but they have operated for nearly two years without trouble at a power level of perhaps a few hundred thousand kilowatts.

The total weight of a pile, including the massive shielding, amounts to some thousands of tons, but it is, nevertheless, a very compact unit for the amount of power which is generated in it.

Production of Useful Power

The energy generated in the Hanford piles is removed by the cooling water which issues at a temperature considerably below 100° C.—too low a temperature for efficient conversion of the heat to useful power. If such a pile is to have general industrial applications, such as the generation of steam and the generation of electric power, it must be run at a much higher temperature. To do this will necessitate considerable changes in design and in operating technique.

It would probably be possible to use liquid bismuth as coolant instead of water, and it might be an advantage to use some other material than graphite as moderator. Progress on these lines demands the solution of some awkward engineering and metallurgical problems; but there is no reason to suppose that the difficulties cannot be overcome.

The most striking characteristics of atomic energy reactors are their compactness for large power capacity and their ability to run for long periods with little or no refuelling.

The power available from an atomic energy reactor is limited essentially only by the rate at which the heat can be removed from it, so that a million-kW. plant need be no bigger than a normal electric power sub-station.

The energy released in the combustion by fission of 1 lb. of U235 or plutonium is rather more than 11 million kWh., equal to the amount of energy which can be obtained from about 1,500 tons of coal or 250,000 gallons of fuel oil. Thus an atomic energy unit may be able to run for long periods on one charge of fuel, and the cost of transport of fuel will, in any event, be small.

Moreover, the plant may, under appropriate conditions, be able to regenerate some, if not all, of its fuel. This arises from the possibility of designing the plant so that some of the neutrons released in fission are used to produce plutonium in uranium, disposed in a suitable way inside or outside the reactor, which will replace the U235 or plutonium which is burned.

This process of replacement takes place in the Hanford piles, where U235 is indirectly converted into plutonium. It may be possible under some conditions to arrange that as uranium 235 is burned the reaction could continue by burning the plutonium, and in this way most of the uranium 238 as well as the 235 might be utilized.

This relative freedom from supply problems, once the plant is set up, opens up the possibility of stimulating industrial development in isolated parts of the world, where coal- or water-power are not readily available. For the same reason, it might prove advantageous to establish atomic energy units in close proximity to mines, more especially in those cases where the ores have to be transported long distances in their crude states.

They may also find application in large ocean-going vessels, in cases where it is desired to avoid frequent refuelling. This application is somewhat more questionable on account of some aspects of atomic reactors, to which I shall refer later.

We must not forget, however, that these bright prospects for the peaceful applications of atomic energy depend on the solution of difficult engineering problems, and that no reactor has yet been developed, or, I believe, even designed, which is suitable for the purposes I have mentioned. Nor must we forget the limitations and disadvantages to which the atomic energy unit is subject, and which are inherent to it.

One of the most serious disadvantages from the point of view of general industrial use arises from the fact that an atomic energy reactor is a source of very intense and very dangerous radiations. A reactor operating at a power level of 1 watt produces as many γ-rays as a few grams of radium (without the radiations from the fission products) and some neutron radiation as well. Although a considerable fraction of these radiations will be absorbed in the reactor itself, shielding is required in order to protect personnel in the vicinity. Even in the case of a very compact unit, the weight of shielding will be considerable.

For example, let us take the case of a reactor dissipating (not generating as useful energy) 100,000 kW. This cannot be much less in size than a 1-metre cube, having regard to the difficulty of the problems of heat transfer. It is easy to show that the weight of the shielding required to reduce the radiations from this unit to a safe level would be a few hundred tons. Even a low-power reactor will need shielding at least 50 to 100 tons in weight, and this factor alone prohibits the application of this type of power to motor-cars or any small mobile units.

Another limitation in the application of atomic energy is that a relatively large amount of fissile material is required even for a low-power unit. This arises from the fact that a 'critical size' is necessary before the chain reaction can develop. Thus, for some time to come, the minimum cost of materials for a power unit may be many thousands of pounds, and it becomes uneconomic to use atomic energy for small plants.

Another consideration is that practically every material which is incorporated in the construction of an atomic reactor becomes radioactive owing to its exposure to neutrons. For this reason, special provisions would have to be devised for maintenance.

The intense γ- and neutron-radiations also have an effect on the structural properties of the materials entering into the construction of the reactor. Owing to their ionizing properties, these radiations destroy the molecular bonds of many molecules. The choice of substances which can be used is, therefore, restricted to those which tend to return to their original state after intense ionization, such substances as elements and simple ionic compounds. How far even these will endure the very great irradiations resulting from large power outputs is not known, for experience is still very meagre. This effect may possibly set a limit to the power output of an atomic reactor and even to its life.

A further difficulty may be caused by the fission products, more especially in the case of the natural uranium reactor. Some of these fission products may absorb neutrons so strongly that after some time the

chain reaction will be inhibited. In such a case, it would be necessary to remove the uranium, extract the fission products, and either to recharge the reactor with new metal or to recover the uranium and to replace it, adding sufficient plutonium or U235 to make it reactive.

Of necessity, all reactors manufacture fission products. At some stage or other, it will ultimately be desirable to remove them. Their disposal may prove to be an awkward problem.

Cost of Power Derived from Atomic Energy

So far as the *immediate* future is concerned, the application of atomic energy to the production of power is not likely to result in a net decrease of overall costs to the community.

Owing to the difficult and tedious nature of the processes for preparing U235 or plutonium in high concentration, reactors depending on such materials for fuel will be far more costly to run than existing hydro-electric or steam-power plants, and the most favourable comparison at the present time will be given by the natural uranium reactor.

Recently an American committee has made a careful study of the costs of building and operating a natural uranium reactor to deliver 75,000 kW., and has concluded that the over-all cost of power would be only about 25 per cent greater than for a coal-burning power plant. This estimate is based on the assumption of a high operating temperature of the uranium reactor, that is, on the performance of a plant which has not even been designed, let alone built. It does not, therefore, represent the present position, but the possible position in a few years time, when research and development have provided the solution of a number of difficult technical problems. The committee's estimate is nevertheless valuable in indicating the possibilities which can already be foreseen. It is not unreasonable to expect that future development of atomic energy will result in a material reduction of costs, and perhaps make the uranium reactor a direct competitor with other power plants.

At the present moment it seems that the use of atomic power plants would be justified, on a purely economic basis, only in the special circumstances I have previously mentioned, where the power needed to develop resources is either very costly or unavailable, or because of difficulties of transport.

What is needed now is intensive research and development in the technical problems which are involved in the applications of atomic energy. This will not only clarify our present somewhat vague ideas, but it may well be that quite new lines may be opened up.

The Future

In assessing the possibilities of future development it is well to remember not only that the art is in its infancy, but also that the preoccupation of the war years with the military aspects of atomic energy has excluded almost completely the consideration of industrial applications. These military aspects still have, and, until some far-reaching international agreement on the control of such weapons is obtained, are bound to have, a retarding influence on peaceful developments, for the reason that the paramount need for security prevents that wide dissemination of knowledge which promotes free exchange of thought, stimulates discovery, and gives an impetus to invention and development.

At this early stage in our knowledge of these matters one cannot hope to see clearly into the future, but only to discern the probable lines of progress. Upon further investigation some lines we now have in mind may prove fruitless, but if we can be guided by the history of scientific and technical development, it is more than likely that others will give a rich reward. A few short years ago what has even now been accomplished would have been considered an idle dream.

Already a military weapon of unparalleled power has been created; enormous amounts of radioactive material have been manufactured; substances which have, owing to their inherent instability, become very rare or even completely disappeared from the cupboard of Nature, have been built up by individual nuclear transmutations and collected in large quantities; and the first steps have been taken towards the development of these new energy sources for industrial application.

This new enterprise constitutes a far deeper interference with the natural course of events than anything which has been attempted hitherto, and it is a most remarkable example of the powers of physical science and engineering and of our increasing control over the processes of Nature. It is not easy at this early stage to survey in detail the consequences which may flow from this advance in the years to come, but it can scarcely fail in the long run to bring about a new outlook and a new situation as regards human resources.

DR. JAMES HUTTON AND THE MANUFACTURE OF SAL AMMONIAC

By ARCHIBALD CLOW and NAN L. CLOW

THE hundred and fiftieth anniversary of the death of Dr. James Hutton (1726–97), the celebrated geologist, which occurred on March 26, brings to mind a little-known phase in the utilization of the products of coal distillation, the profits from which are said to have secured to Hutton the leisure necessary for his geological speculations.

In his "History of Inventions and Discoveries", J. Beckmann says: "If I am not mistaken, the first manufactories of sal ammoniac were established in Scotland: the oldest of these, perhaps, was that erected by Dovin and Hutton at Edinburgh in 1756"[1].

This refers to a co-partnership formed by Dr. James Hutton and someone variously described as James Dovin, Dairy, or Davie, in Edinburgh according to a plan conceived when they were Edinburgh students. In Kay's "Portraits"[2], the date of formation is given as before 1749, which may be right, since Hutton went to a Norfolk farm to study agricultural methods in 1752.

The raw material used in this early chemical manufacture was soot, and for a number of years Davie took all the soot collected by Edinburgh 'tronmen'—a chimney sweeps' society formed in 1738[3]. The process was carried out as follows: "Globular glass vessels, about a foot in diameter, are filled to within a few inches of their mouth with it [soot], and are then arranged in an oblong furnace, where

they are exposed to a heat gradually increased. The upper part of the glass balloon stands out of the furnace, and is kept relatively cool by the air. On cooling, the upper parts of the globes are found to be lined with sal ammoniac in hemispherical lumps, about 2·5 inches thick. 26 lbs. of soot yield 6 of sal ammoniac."

There is a reference to the manufacture of sal ammoniac in Edinburgh, and to green glass globes used in the manufacture, in a letter from John Findlay, secretary to the Duke of Richmond, to George Macintosh, the Cudbear and Turkey red manufacturer, and it seems probable that the vessels used by Hutton and Davie were old vitriol bottles from the Prestonpans Vitriol Works, founded by Dr. John Roebuck and Samuel Garbett in 1749 [4].

The firm of Hutton and Davie was still in existence in 1783, and in that year they began buying sal ammoniac, probably crude, from the tar works established at Culross in 1781 by Archibald Cochrane, ninth Earl of Dundonald.

Dundonald's sal ammoniac was one of the by-products of his tar manufactory. The preliminaries in the negotiations for the sale of the sal ammoniac to Hutton and Davie are referred to in the report that Dr. Joseph Black, professor of chemistry in Edinburgh, prepared for Andrew Stuart, when the latter was trying to ascertain the likely success that might attend the founding of the British Tar Co. After going into the details of prospective profits from the sale of tar and coke, Dr. Black goes on: "There is one article omitted above, which is a quantity of Volatile Alkali formed in the water condensed along with the tar from the vapour of the coals. The volatile alkali, after being somewhat refined from the oil and water can be employed in the manufacture of sal ammoniac: and My Lord having sent a specimen of his prepared or purified alkali to Mesars. Hutton and Davie who manufacture sal ammoniac here, I know that they found it good for the purpose and made his Lordship an offer for a certain quantity annually, the consumption of sal ammoniac being limited. But I do not know what offer they have made, or what profit this article is capable of yielding. They have hitherto extracted their volatile alkali from soot, which is also produced by the condensation of vapour from coals"[5].

Evidently Lord Dundonald hoped to make a considerable business by working up this side-line, because he wrote Andrew Stuart, his uncle: "My partners and I have it in our Power to render him [Glassford]* very essential service by purchasing from him annually some Thousand Pounds worth of a commodity he manufactures concerning which I shall explain myself more fully when I have the pleasure of seeing him in Scotland"[6].

The latter refers to the purchase of either sulphuric acid or hydrochloric acid, to be used in the manufacture of sal ammoniac.

Dundonald sent a William Kinnaird, chemist and apothecary, to London in 1784 to learn the best way of making sal ammoniac. Dundonald and his two brothers, John and Alexander, who were already his business associates in the British Tar Co., were to join Kinnaird in the manufacture; but difficulties arose over Kinnaird's wages, and it is said that he did everything he could to sabotage Dundonald's enterprise because he wished to start on his own[7].

* Glassford of Dougaldston, a principal partner in the Prestonpans Vitriol Co.

The method of manufacture employed by Dundonald was probably that invented by M. Leblanc of St. Denis, near Paris, with this difference, that Leblanc got his ammonia by the destructive distillation of organic matter, whereas Dundonald's ammonia was produced by the action of heat upon nitrogenous matter in coal. The ammonia was combined with hydrochloric acid, which was produced in a brick kiln by the action of sulphuric acid on the sea salt he could obtain from his own pans at Culross[8].

None the less, soot continued to be used as a raw material, both by Hutton and Davie, and also in a new manufactory which was founded by Charles Macintosh at Glasgow in 1786, in partnership with his father, George Macintosh, of the Cudbear and Turkey Red Works, and a Mr. William Couper, an eminent Glasgow surgeon.

The Macintosh factory continued for a number of years, but it is probable that more scientific methods of making sal ammoniac led to its being closed down[9]. In any event, by 1814, according to Sir John Sinclair, there was only one sal ammoniac works of any size in Scotland, and that was at Bo'ness[10]. There Joseph Astley operated a patent process similar to that referred to in the *Annales de Chimie* of 1797 (20, 186), which used 'bittern' from the salt works as a raw material. From this factory sal ammoniac was retailed at £9 10*s*. 10*d*. per cwt. Considerable details about Astley's process are given by Thomas Thomson in his supplement to the "Encyclopædia Britannica":

"One process more deserves to be mentioned, on account of its ingenuity and simplicity. It is the invention of Mr. Astley, who has secured the exclusive privilege by a patent, and has a manufactory at Borrowstowness, on the Firth of Forth, and another at Portobello, near Edinburgh. He mixes together animal matter (chiefly woollen rags), and what in Scotland is called *spirit of salt*. It is the mother ley that remains after all the crystals of common salt that can be got have been separated from sea-water. It consists chiefly of muriate of magnesia. This mixture is burned in furnaces, and the produce received in small chambers placed over the furnaces. This produce contains abundance of sal ammoniac, which is obtained pure by sublimation. We conceive the theory of this process to be, that the carbonate of ammonia is formed by the combustion of the animal matter. This carbonate immediately decomposes the muriate of magnesia, and sal ammoniac sublimes. In principle, therefore, it does not differ from Baume's original process, though, in point of economy, it is probably greatly superior to it."

Hutton died in 1797, and Davie not long after. Following Davie's death, it appears that Edinburgh soot was sent to Walker's works at Beverley, Yorks, because we learn that Astley, who is described as an extensive chemical manufacturer in Portobello, was involved in a legal action in the Court of Session through one of his clerks inveigling two or three members of the Edinburgh Tronman's Society (chimney sweeps) into a public house and persuading them to sign an agreement on behalf of the Society to supply Astley with all the soot they collected instead of sending it to Yorkshire[11].

The next phase in the utilization of coal by-products is the well-known development of the gas industry in the first two decades of the nineteenth century. The new information which we have set forth concerning the prior utilization of coal by-products throws new light on the economic back-

ground of the gas industry. It also gives a new perspective to the growth of experimental chemistry during the latter half of the eighteenth century; and it is worth bearing in mind that when Joseph Priestley discovered ammonia, he was exploring the properties of a substance of established utility as a saleable by-product of coal.

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NATURE OF VIRULENCE

THE term 'virulence' has sometimes in the past been regarded as an intrinsic property of an infecting agent; that such a view is not entirely in accord with our knowledge of natural and experimental infections was apparent from the discussion on the nature of virulence at the meeting of the Society for Microbiology held in London on December 20. As virulence can only be measured in terms of the effect on the host by a micro-organism, using that term in its widest sense, it is obvious that the interaction between the micro-organism and host by which we estimate virulence will depend on many variables affecting both participants. Much of the discussion related to these variables and their effect on virulence. A very wide field was covered, contributions on the virulence of bacteria, of fungi and of viruses for both plant and animal hosts and of the parasitic protozoa being made by various speakers. It was generally accepted that multiplication of an infecting agent in the body of the host does not alone determine virulence, and that the term 'virulence' necessarily implies structural or functional damage to the tissues of the host.

It is clear that the morphology and physiology of plants are so different from those of animals that virulence of phytopathogens involves mechanisms different from those concerned in virulence of micro-organisms for animals. This point was clearly illustrated by Mrs. Dagny Oxford in her discussion of bacterial virulence in plants; the bacteria virulent for plants, unlike most of the animal pathogens, are free-living, relatively resistant and simple in their nutritive requirements. As most of these species do not split cellulose, they depend for their entry into plant tissues on abrasions or wounds. There may be some correlation of virulence of phytopathogenic bacteria with the power to produce pectolytic enzymes, and in some instances cell-free filtrates of bacterial cultures produce reactions in the plant tissues similar to those caused by the living bacteria. Mrs. Oxford pointed out that the resistance of plants to bacterial infection is a function of the local tissue cells and does not depend on any humoral mechanism such as operates in the resistance of animals to invading bacteria.

Fungi are, however, more important disease-producing agents in plants than are bacteria, and Prof. E. Gäumann of Zurich made a most interesting contribution in this field to the symposium. The necessary attributes for virulence were discussed in relation to different types of pathogenic fungi, the part played by the host tissues being emphasized. The damage to plant tissue appears in the case of one fungus to be due to a polypeptide which destroys the semipermeability of the plasma boundary layer; but the power to produce this substance *in vitro* is not of itself sufficient to determine virulence. The power to penetrate the plant tissues by the production of certain enzymes and to withstand the reactions of the host tissues are also necessary. In plant infections due to more than one fungus (mixed infections), the resulting disease may be dependent on the interaction of the infecting fungi and may not be controlled by the most virulent strain.

In his discussion on the virulence of bacteria in animals, Dr. D. W. Henderson pointed out that it is difficult to induce parasitism in normally saprophytic bacteria, and that this lack of virulence is due in some instances, although perhaps not in all, to their lack of power to multiply in the living body. In general, toxicity is inversely proportional to the degree of tissue invasion by a pathogenic bacterium. The species of the animal host, its physiological state, and its genetic constitution may all influence the virulence of a bacterial infection. Other points mentioned by Dr. Henderson as bearing on virulence concerned aggressins, route of entry of a bacterium into the body, and the synergistic action of other bacteria. The importance of the last two factors was later referred to by Dr. C. H. Andrewes in relation to the virulence of viruses for animals.

That apparent increase of virulence in a parasitic micro-organism may in fact be due to lessened resistance of the host was exemplified by Dr. J. T. Duncan in his contribution on virulence of ringworm fungi in animals. These fungi are frequently highly parasitic and highly infectious but of low pathogenicity, and the host parasite equilibrium may remain undisturbed for years. On the other hand, some of the normally saprophytic fungi may become highly pathogenic, producing severe systemic disease; and in some of these fungi pathogenicity is associated with the property of dimorphism, the organism being capable of developing, in place of the complex mycelial saprophytic form, a simple form adapted for rapid reproduction and invasion in animal tissues. In the case of such fungi, as with some of the ringworm fungi when implanted on an unusual animal host, high pathogenicity may be associated with low infectivity.

The parasitic protozoa afford instructive examples of variations in the host parasite relationship in relation to virulence. Prof. H. E. Shortt illustrated the state of true symbiosis between certain protozoa and their vertebrate or invertebrate hosts, and from the symbionts and commensals went on to consider the parasitic protozoa. Some of these may multiply without producing disease, but this balanced parasitism might be readily upset. The mechanism by which disease is produced by pathogenic protozoa is not clearly understood; no true toxins are demonstrable, and in some cases disease is due to mechanical

effects resulting from extreme proliferation of the parasites in particular cells or tissues; for example, certain trypanosomes in the reticulo-endothelial cells or muscle, and the malaria parasite in blood cells. Death of such highly parasitized hosts is frequently due to super-added infection with bacteria or other infecting agents. In the state of latent or chronic protozoal infection, it can be shown by transfer to fresh hosts, or by measures which lower the resistance of the chronically infected animal, that the protozoan has not lost its virulence. On the whole, it seems that for this class of micro-organism (as for the viruses and certain of the more parasitic bacteria) excessive virulence is a disadvantage to the parasite from the point of view of survival of the species, and virulence may represent the initial stages of association between the parasite and host, to be succeeded by commensalism or symbiosis.

The virulence of viruses for plants or animals must be considered only as a virus-host relationship, as the known viruses are essentially parasitic. Both Dr. Kenneth Smith and Dr. C. H. Andrewes stressed the variations in virulence manifested in virus-host associations according to variations artificially induced or arising naturally in the infecting virus, or depending on host factors and particularly on host species. The highly virulent virus which always produced death of the tissues or whole plant would, as Dr. Smith pointed out, have difficulty in transmission to fresh hosts and thereby in ensuring survival. Such plant viruses, however, while apparently possessing intrinsic virulence for one plant, usually infect other plant hosts without producing symptoms. Variations in virulence can be produced by various procedures which probably favour selectively the multiplication of a virulent variant already present in the virus strain. The emergence of virus mutants under laboratory conditions was also mentioned by Dr. Andrewes, who suggested that the selective survival of mutants showing antigenic variations from the original virus may explain the course of certain human epidemic diseases. From several viruses stable variants can be produced by adaptation to a new host species. The highly virulent virus is able to multiply extensively in invaded host cells, and to destroy these cells with liberation of virus for the attack on further cells. Although the mechanism responsible for cell destruction is not known, recent work with rickettsiæ and influenza virus suggests that these agents in the living state, if present in sufficient concentration, can exert a toxin-like action. Virulence of the animal viruses may also depend upon special tissue affinities, as in the neurotropic viruses. The adaptation of virus to host which results in latent infection may, as in other host-parasite associations, be readily upset.

Prof. A. W. Downie, in summing up the discussion, referred to various points made by previous speakers and suggested that the host-parasite relationship studied under experimental conditions might not show the manifestations of virulence which are evident under field conditions as shown by the behaviour of epidemic disease. We are ignorant of the mechanism by which damage to the tissues of the infected host is produced, and in this field there seems much to be done in the study of the biochemical interactions of parasitic micro-organisms or their enzymes and toxins with the metabolic processes of the host cells.

OBITUARIES

Prof. Robert Newstead, F.R.S.

ROBERT NEWSTEAD was justly proud of the fact that the high place which he achieved for himself in the scientific world, and the distinction which he brought to the Liverpool School of Tropical Medicine and to his adopted city of Chester, were won by him in face of almost insuperable obstacles, associated with an interrupted schooling and an absence of university training or contacts, until he was more than forty years of age.

Newstead, whose death occurred on February 16, was born on September 11, 1859, at Swanton Abbott, Norfolk, and received his early education at a village elementary school, from which he not infrequently played truant in order to be out in the fields and the woods, watching bird- and animal-life. At the age of ten he left school and was apprenticed to the village post and telegraph office, which included also a printer's and stationer's works. There, during the period of the Franco-Prussian War, Newstead became familiar with the processes of printing and studied telegraphy, in which he passed one examination. From telegraphy he passed to gardening and a little farming, devoting his spare time to the study of a small text-book of zoology, from which he taught himself the elements of systematic study, and to the collection of specimens of plant-, animal- and bird-life. One such collection, made primarily for his own pleasure, led to the beginning of his long connexion with Chester. In 1883, at the age of twenty-four, he was invited to exhibit a collection of Norfolk insects, birds and fungi at the Town Hall, Chester. His specimens attracted the attention of the late Mr. Alfred Walker, a disciple of Charles Kingsley and an ardent naturalist, who straightway offered him an appointment in his gardens, partly as gardener, partly as naturalist.

While holding this appointment, Newstead was present at the laying of the foundation stone of the Grosvenor Museum, Chester, and in 1886, when the Museum was opened, he realized one of his early ambitions by being appointed its first curator. The curatorship of the Museum was held for nineteen years, during which time Newstead was responsible for arranging and describing the exhibits in the natural history and archæological sections, both of which were enriched by many specimens which he personally prepared and mounted, not only during his tenure of office, but also long after his retirement; and I have seen him busy with this work after he had passed the age of eighty-five.

In 1906 Newstead was appointed lecturer in economic entomology and parasitology at the Liverpool School of Tropical Medicine, six years after its foundation as the first school of tropical medicine in the world, and at a time when it numbered on its staff such eminent men as Sir Ronald Ross and Sir Rubert Boyce. The importance of Newstead's work now began to receive wider recognition; in 1908 he received the degree of master of science *ex officio* in recognition of his scientific achievements, and in 1911 he was elected first holder of the Dutton Memorial chair of entomology in the University of Liverpool. From that time until his retirement from the chair in 1924, Newstead held a leading place in the world of entomological research. He was dispatched on two scientific expeditions organised by the Liverpool School of Tropical Medicine: first, to

Jamaica in 1908, to make investigations into the causes of the prevalence of sarcoptic mange among cattle; and secondly, to Malta in 1910, to study the bionomics of sandflies. In 1911 he worked on the Royal Society's Sleeping Sickness Commission in Nyasaland, where he spent five months in the bush investigating the breeding-places and habits of the tsetse fly; and during 1913–14 he was a member of the inter-departmental committee on the same disease. During the First World War he was engaged by the War Office to take charge of the Entomological Commission appointed to investigate methods for the control of fly-borne diseases occurring in the camps of France and Flanders, and directed the Liverpool centre of investigation set up by the Royal Society Grain (Pests) War Commission, 1916–20, to deal with the damage caused to grain by insects and mites during transit and in store. He was elected a fellow of the Royal Society in 1912.

Entomology, however, was not the only subject upon which Prof. Newstead was an authority. His appointment as curator to the Chester Museum marked the beginning of his interest in the study of the Roman occupation of Chester. So early as 1899 he was writing on Roman remains which had recently come to light in Chester and Penmaenmawr. In 1914 he began active digging, and from that time onwards, until a few months before his death, he took a large part in excavating, preserving and describing Chester's Roman antiquities. These discoveries and the resultant additions to our knowledge of the Roman occupation were fittingly recognized by the citizens of Chester in 1936, when they conferred upon him the honorary freedom of the city.

During his life-time, Newstead published more than two hundred papers and, since he was an artist of considerable ability, many of them were illustrated by his own hand. As might be expected from such a long, diligent and far-seeking career, these papers covered a wide range of entomological and archæological subjects; but essentially Newstead was a biologist of the old school, a trained observer of Nature, and one who was at his best and happiest in the open air.

We regret to announce the following deaths:

Sir Joseph Barcroft, C.B.E., F.R.S., emeritus professor of physiology in the University of Cambridge, on March 21, aged seventy-four.

Prof. Pierre Janet, well known for his work on psycho-pathology, on February 24, aged eighty-seven.

NEW FELLOWS OF THE ROYAL SOCIETY

At the meeting of the Royal Society on March 20, the following were elected fellows:

Dr. W. J. Arkell, formerly senior research fellow of New College, Oxford, distinguished for his researches on the stratigraphy and palæontology of the Jurassic system; he is the author of valuable palæontological monographs on the Lamellibranchs and Ammonites of the British Corallian.

Dr. G. M. Bennett, Government Chemist, distinguished for his work in organic chemistry on the reactivity and configuration of organic molecules.

W. S. Bisat, civil engineer, Collingham, near Leeds, distinguished for his studies in Carboniferous stratigraphy and palæontology; his methods have been successfully applied in Europe and North America.

Mary Lucy Cartwright, fellow of Girton College and lecturer in mathematics in the University of Cambridge; distinguished for her researches in the theory of functions of a complex variable.

Prof. E. J. Conway, professor of biochemistry, University College, Dublin, distinguished for his work on chemical and physico-chemical processes in living tissues.

Prof. T. G. Cowling, professor of mathematics in the University College of North Wales, Bangor, distinguished for his mathematical contributions to astronomy, the theory of gases, the physics of the ionosphere, and geomagnetism.

J. Craigie, member of the scientific staff of the Imperial Cancer Research Fund, London, distinguished for his work in bacteriology and immunology, and especially for his studies of viruses.

M. B. Crane, head of the Pomology Department of the John Innes Horticultural Institution, London, a notable breeder of new varieties of horticultural plants, whose researches have elucidated the genetical constitution and origin of cultivated English fruit trees and unravelled many problems relating to pollination and the setting of fruit.

Prof. W. J. Duncan, professor of aerodynamics at the College of Aeronautics, Cranfield, distinguished for his contributions to an understanding of flutter in aircraft, and of related problems of elasticity and vibrations.

Prof. M. G. Evans, professor of physical chemistry and head of the Department of Chemistry, University of Leeds, distinguished for his contribution to chemical kinetics and especially for his theoretical work on the modern concepts of reaction velocities.

Dr. W. S. Feldberg, lecturer in physiology, University of Cambridge, distinguished for researches on the mechanism of the humoral transmission of excitation, particularly in relation to the phenomena in which acetylcholine is concerned.

T. Goodey, principal research officer, Institute of Agricultural Parasitology, St. Albans, distinguished for his work on the structure, life-histories and economic importance of nematode worms, particularly those parasitic on plants.

Dorothy Crowfoot Hodgkin, fellow and tutor of Somerville College, Oxford, and University demonstrator in chemical crystallography, distinguished for a long series of investigations by X-ray crystal analysis into the structure of the sterols, proteins and other complex organic molecules.

J. Hutchinson, keeper of the museums, Royal Botanic Gardens, Kew, distinguished for his researches on the taxonomy and affinities of flowering plants and his contributions to the study of the flora of Africa.

Dr. D. A. Jackson, lecturer in spectroscopy, University of Oxford, distinguished for his method for separating close spectral lines and measuring their wave-lengths; by this means he was the first to determine magnetic and mechanical moments of various atomic nuclei.

Prof. G. Jefferson, professor of neurosurgery in the University of Manchester, distinguished for the leading part he has played in the development of the surgery of the brain and spinal cord, in the treatment of head injuries, and for his studies of the physiological disorders resulting from brain injury.

Prof. H. A. Krebs, professor of biochemistry, University of Sheffield, distinguished for his work on intermediary reactions in cell metabolism.

Dr. F. G. Mann, reader in organic chemistry and fellow of Trinity College, Cambridge, distinguished for his work on stereochemistry with particular reference to complex metallic salts and derivatives of arsenic, phosphorus and antimony.

Prof. P. B. Moon, professor of physics, University of Birmingham, distinguished for his researches in atomic physics and for his contributions to the development of micro-wave radar and to the subject of atomic energy.

Dr. E. Orowan, Cavendish Laboratory, Cambridge, distinguished for his fundamental contributions to the physics of metals; his work on plastic deformation, fracture and fatigue is characterized by particular originality and elegance.

Prof. F. A. Paneth, professor of chemistry, University of Durham, distinguished for his pioneering researches in radio-chemistry and for the discovery of free organic radicles of short life; he has undertaken chemical and radio-chemical work in connexion with atomic energy.

Muriel Robertson, head of the Department of Protozoology of the Lister Institute, London, distinguished for researches on the life-cycles of Protozoa and on immunology.

Prof. F. J. M. Stratton, professor of astrophysics, University of Cambridge, fellow of Gonville and Caius College, and general secretary, International Council of Scientific Unions, distinguished for his researches on novæ, and for his part in planning and organising work for the observation of eclipses.

Prof. C. H. Waddington, professor of animal genetics, University of Edinburgh; chief geneticist of the Animal Breeding Research Organisation (Agricultural Research Council); distinguished for his work on experimental embryology and its relation to genetics.

Air Commodore F. Whittle, adviser (engines) to the Controller of Supplies (Aircraft), Ministry of Supply, distinguished for his work on jet propulsion.

NEWS and VIEWS

Coal Gas and Fuel Industries at the University of Leeds: Prof. A. L. Roberts

In 1910 the gas industry endowed the Livesey chair at the University of Leeds to perpetuate the memory of Sir George Livesey, the eminent engineer of the South Metropolitan Gas Company. It was first held by W. A. Bone, who was followed by J. W. Cobb in 1912, and by D. T. A. Townend in 1938. When in 1945 the University granted Prof. Townend leave of absence to take charge of the British Coal Utilisation Research Association (*Nature*, **155**, 783; 1945), Dr. A. L. Roberts, senior lecturer in refractory materials, was appointed acting head, and he has now been appointed to the chair.

Educated at Christ's Hospital, Horsham, Prof. Roberts held an Ackroyd Scholarship at Leeds, and afterwards undertook research under the direction of Prof. R. Whytlaw-Gray into the redetermination of the atomic weight of silicon. In 1930 he was appointed demonstrator in refractory materials in the Department of Coal Gas and Fuel Industries, in succession to Dr. (now Sir) Hubert Houldsworth, a field in which, after collaborative research with Prof. Cobb, he rapidly became eminent. In recent years Prof. Roberts has taken a leading part in the research associated with the gas industry, under the Joint Research Committee of the University of Leeds and the Gas Research Board, for which the University is renowned, specializing in the newer applications of radiant heat to drying, etc., processes. He has also collaborated with the Yorkshire Industrial Gas Development Centre in the development of the permeable lining principle in furnace practice, and with the British Refractories Research Association in an investigation into long-dated effects which occur in siliceous refractories used in carbonizing plant. In another field he has studied the influence of constituent minerals on the working properties of refractory materials, revealing a new species of kaolinitic mineral in plastic fireclays; and during the Second World War he undertook Government work upon the fundamentals of recrystallization of highly refractory materials, an important research since then supported by the Department of Scientific and Industrial Research, and having wide applications, including that in gas turbines, etc. In this connexion he visited Germany in 1945, and has served on a number of Government committees. He has been closely associated with the recent developments in chemical engineering in the University of Leeds, and is a leading figure in local sections of several professional bodies in the Yorkshire area.

Meteorological Stations in the Arctic

The Canadian Government, in close association with the Government of the United States, is planning the establishment of nine meteorological stations in the Arctic. The project will probably take several years to complete, because of the limited period each year during which the sea north of the Arctic Circle is navigable. It is intended that the stations, once established, will be supplied by air. Meteorologists have long felt the need for an increase in the number of stations making regular weather reports in the Arctic regions of the North American continent. The principal requirement is not just for short-lived series of surface observations such as are obtained from expeditions, but rather for the operation of fixed stations making *radio-sonde* measurements of pressure, temperature, humidity and wind over a

period of years. The Canadian scheme is therefore expected to provide data of vital importance to general studies on atmospheric circulation and in particular to weather forecasting. This development is of special interest to aviation owing to the increased attention that is being given to the possibilities of inter-continental flying by great circle routes passing over the Polar regions. It is understood that the U.S.S.R. are also anxious to increase the number of meteorological stations in their territory within the Arctic Circle. For this purpose, attempts are being made to develop an automatic weather reporting station that would measure and transmit the values of meteorological elements at regular intervals over a long period.

Ice Accretion on Aircraft

An interesting series of experiments on the Vickers "Viking" airliner by the British European Airways Corporation in conjunction with Messrs. Vickers-Armstrong, the designers and makers of the Viking, has been brought to a successful conclusion. It has been established that the building up of ice on parts of an aircraft can be sufficient to force it down, and that the meteorological conditions necessary to cause this may possibly be met on normal everyday flights. Consequently, equipment for dealing with the trouble must be provided on all machines that are expected to carry out flights to arranged schedules and time-tables. Methods already tried out for dispersing this ice are: (i) application of heat, (ii) cracking the ice by causing the surfaces to pulsate, (iii) spraying the parts with a de-icing fluid. The latter system was adopted by Messrs. Vickers-Armstrong, and the experimental machine carrying it was flown by the B.E.A.C., as operators of an air transport line, under conditions chosen to be as bad as possible. The system was tried both by allowing ice to accumulate and then dispersing it, and by keeping the apparatus working and preventing the formation of ice. The fluid is sprayed over the wings, tail and control surfaces by means of porous metal distributors inset at the leading edges. It is pumped to these and carried back over the surfaces by the airstream, and is controlled manually by the crew or automatically by an ice detector. Normal flow is on an intermittent pulsation of one 'on' and four 'off' strokes; but in an emergency this can be increased to a continuous flow. To wet the surfaces quickly, when the system is first switched on, the normal intermittent flow is automatically preceded by a short flooding period of continuous pumping.

Pilot Papers

Pilot Papers, No. 4, is unfortunately not quite up to the standard of previous numbers in point of scientific interest (1, Nov. 1946. Pilot Press, Ltd. 3*s*. 6*d*.). The articles are too scattered in subject-matter and some of them superficial—too long and too thin—in treatment. The scattering of interest militates against *Pilot Papers* filling an obvious gap in learned sociological periodicals. Departmental libraries of universities, not to mention university specialists, may well hesitate to subscribe to yet another review for the 'general reader'. One article on the income tax is straight public finance, which is already catered for in economic journals; another is social history in autobiographical form. Two articles, clearly of sociological import, one on the 'squatters', the other on an estate of 'prefabs', are both too long for the common-sense and simple conclusions reached—such as that 'prefabs' are popular; though admittedly data on the 'sense of community' are useful to planners. In particular, the photographs of life among the prefabs might well have been halved without missing the peculiar characteristics of the community. A further article is a popularly written account of progress in psychosomatic medicine. The contribution of perhaps deepest interest deals with the question "Do the Germans Feel Guilty?" by direct interrogation of Germans.

The introductory 'commentary' by the editor, Mr. Charles Madge, is, however, disarming and certainly makes the best of interpreting the material presented. The comment on several articles is that they add something which journalists have missed. Certainly, they are super-journalism, but in the absence of comparison, generalization and interpretation, this does not qualify the essays as social science, such as Mr. Madge's own commentary certainly is. *Pilot Papers* have undoubtedly an important part to play in the advancement of the social sciences, at present so backward in Britain. Let us hope future numbers will concentrate more on an anthropological treatment of modern social relations or on comment thereon, less on *rapportage*, however superior.

Glossaries of Geographical Terms in Different Languages

The Royal Geographical Society, through its Committee on Geographical Names for British Official Use, published during the War a number of glossaries of geographical and other terms used on maps of various countries, most of which do not use the Roman alphabet (London: Royal Geographical Society). These glossaries covered Modern Greek, Russian, Albanian, Serbo-Croat and Slovene, Romanian, Siamese and Turkish. The volumes differ a little in scope, but all are glossaries as apart from gazetteers, and they are not concerned with the transliteration of proper names beyond including alphabets and equivalents. Several incorporate new systems of transliteration. Mr. M. Aurousseau, the secretary of the Place Names Committee, contributes to each volume a general article on the writing of geographical names, with a short bibliography on the subject. There are also articles on various linguistic aspects in many of the volumes. The Turkish volume gives both Arabic and Roman script, and the Siamese volume gives both Thai and Roman. These glossaries are invaluable in the utilization of the maps of the countries concerned; nothing else on so comprehensive a scale has been published for a very long time.

Commercial Flower Production

The Ministry of Agriculture and Fisheries has recently reprinted three booklets on the production of ornamental plants for market. Bulletin No. 109 (London: H.M. Stationery Office. 1*s*. 6*d*. net) deals with summer flowers; Bulletin No. 110 (1*s*. net) describes the horticulture of plants with decorative foliage; and Bulletin No. 112 (2*s*. net) considers the treatment of pot plants. All three bulletins have been written by Dr. H. V. Taylor and Dr. Katharine H. Johnstone. A general section on the raising of seedlings appears in each number, and descriptions of the varieties, cultivation and any special technique are given for each species. Length of text for a

particular species is in proportion to its market value, and though the bulletins have no pretence to the encyclopædic, the grower will find that commercial factors have all been dealt with adequately. A number of drawings by L. N. Staniland illustrate the bulletin on foliage; the others have a smaller number of half-tone photographs. Part 1 of the series dealt with spring flowers and flowers grown under glass; it appeared first in 1936. The three booklets now reprinted should provide a modern compendium for growers who may be attempting to restore pre-war floral glories.

Wellcome Marston Archæological Research Expedition

PUBLICATION of the excavations conducted by the late Mr. J. L. Starkey at Lachish (Tell ed-Duwir), Palestine, during 1932–38 is now being resumed. In order to compile a full bibliography, the editor would be glad to know of all articles and other published references to the archæological and linguistic material from the site, particularly those in foreign publications. Copies or extracts, with full references and short summaries of the contents, should be addressed to the Wellcome Marston Archæological Research Expedition, at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1.

Hydrogen-Cooled Turbo-Alternators

THE advantages of hydrogen cooling for large high-speed electrical machines have not up to now been exploited in Great Britain. Several manufacturers are at present engaged on the construction of turbo-alternator units employing hydrogen as a cooling agent. In a report on work and progress in 1946 issued by the Metropolitan-Vickers Electrical Co., Ltd., it is stated that a 60,000 kW., 3,000 r.p.m. set is approaching completion and will be ready for testing shortly.

Prizes for Scientific Instrument Development

THE British Scientific Instrument Manufacturers' Association has received from Mr. W. Bowen a substantial capital sum, the income from which is to be used for the encouragement and development of invention, design, research processes and manufacturing technique in the scientific instrument industry. The Council of the Association has therefore drawn up a trust deed under which the income will be devoted to prizes for employees of members of the Association. This year, five prizes totalling approximately £125 will be awarded for papers coming within the scope of Mr. Bowen's gift. Papers must reach the Secretaries of the Association, Messrs. Binder, Hamlyn and Co., River Plate House, 12/13 South Place, London, E.C.2, from whom application forms can be obtained, not later than April 30.

Colonial Service: Appointments

THE following appointments have been made in the Colonial Service: I. G. Bulmer, to be assistant conservator of forests, Sierra Leone; Captain A. T. Crow, to be geologist, Gold Coast; Captain M. Maughan, to be computer, Lands, Mines and Surveys Department, Uganda; C. A. Gibson-Hill, to be assistant curator, Raffles Museum, Singapore; J. N. Milsum, senior agricultural officer, Malaya, to be chief field officer, Malaya; R. G. H. Wilshaw, senior chemist, Malaya, to be chief research officer, Malaya; H. C. King, assistant conservator of forests, Mauritius, to be senior assistant conservator of forests, Sierra Leone.

The Night Sky in April

FULL moon occurs on April 5d. 15h. 28m., U.T., and new moon on April 21d. 04h. 19m. The following conjunctions with the moon take place: April 8d. 22h., Jupiter 0·6° N.; April 18d. 06h., Venus 4° N.; April 19d. 06h., Mercury 2° N.; April 19d. 07h., Mars 4° N.; April 27d. 13h., Saturn 4° S. In addition to these conjunctions with the moon, Mercury is in conjunction with Mars on April 19d. 23h., Mercury being 1·8° S. Mercury rises about half an hour before sunrise at the beginning of April and attains its greatest westerly elongation on April 5. At the middle and end of the month the planet rises about 20 minutes and 10 minutes respectively before sunrise, and is not favourably placed for observation. Venus can be seen as a morning star, stellar magnitude −3·5, rising at 4h. 40m., 4h. 18m., and 3h. 56m. at the beginning, middle and end of the month, respectively. The visible portion of the illuminated disk varies between 0·748 and 0·820 during April. Mars is too close to the sun for favourable observation. Jupiter can be seen late in the evening in the constellation of Libra, and rises at 22h. 45m. on April 1 and 20h. 35m. on April 30. Its stellar magnitude is −2, and its altitude is not more than 21° in the latitude of Greenwich as its declination is far south. Saturn can be seen up to the early morning hours in the constellation of Cancer, setting at 3h. 31m., 2h. 37m., and 1h. 40m., at the beginning, middle and end of the month, respectively. The following occultations of stars brighter than magnitude 6 take place: April 23d. 20h. 28·4m., 247 B. Taur. (*D*); April 26d. 23h. 15·7m., x Gemi. (*D*); April 29d. 19h. 56·3m., 46 Leon. (*D*); *D* refers to disappearance, and the latitude of Greenwich is assumed. During April 18–24 the Lyrid meteor shower is active, the radiant being about R.A. 18h., Dec. +33°.

Announcements

THE following appointments have been made in the University of Leeds: Dr. Philip George, as Brotherton research lecturer in physical chemistry; Dr. G. E. Pringle, as lecturer in inorganic and physical chemistry.

A COURSE of eight lectures on microscopy will be given in the Physics Department, Imperial College of Science and Technology, London, S.W.7, by B. K. Johnson on Tuesdays and Thursdays at 4 p.m., commencing on April 29. The lectures will be accompanied by practical demonstrations and will include modern methods. They will be suitable for those having to use the microscope in technical practice. Application for admission should be made to the Registrar of the Imperial College, Prince Consort Road, S.W.7.

THE twenty-first National Colloid Symposium will be held at Stanford University, Palo Alto, California, during June 18–20, 1947, under the auspices of the Division of Colloid Chemistry of the American Chemical Society. The programme will consist of two groups of papers; one of these will be built about the subject "Colloidal Electrolytes"; the other will be made up of papers on general colloid chemistry. Particulars of the meeting can be obtained from Prof. J. W. Williams, Department of Chemistry, University of Wisconsin, Madison 6, U.S.A.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Use of Punched Card Tabulating Machines for Crystallographic Fourier Syntheses

THE use of 2-dimensional Fourier syntheses in the determination of crystal structures from X-ray data has been well established for some years; but it is becoming increasingly recognized that for detailed determinations these alone are not enough, and that 3-dimensional syntheses are also necessary. The methods of summation which have been used for 2-dimensional work[1], and which employ no other mechanical aids than adding machines, can be applied to 3-dimensional problems, but are then comparatively slow and impose a considerable strain on the computer. Moreover, with rising standards of accuracy, some improvement is desirable on the existing Beevers–Lipson strips which have so far been most commonly used for 3-dimensional work; the 'rounding-off' errors arising from the use of the strips, with their 2-figure accuracy and 6° intervals of computation, may in unfavourable cases lead to displacements of atomic centres by 0·01 A., which is now no longer small compared with the accuracy theoretically attainable[2].

The possibility of carrying out syntheses by means of punched card tabulating machines has been appreciated for some time[3], and several 3-dimensional syntheses have been performed in Great Britain by the Scientific Computing Service, Ltd., while recently Shaffer, Schomaker and Pauling[4] have described a method for use with American tabulating machines. In order to fulfil our requirements for a simplified punched card method, capable of operation locally, we have developed independently the method outlined below; this, while not essentially different in principle from that of Shaffer *et al.*, is considerably simpler, so that the selection of cards can be done by any research worker in a reasonable time and without special training, and can be carried out on Hollerith machines of the type commonly available in Britain. The machines do not have to be adapted specially or set aside for crystallographic work only, so that syntheses or parts of them, occupying, say, two or three hours, can be done in intervals between the normal commercial work of the machines.

We have in effect reproduced Beevers–Lipson strips on Hollerith cards, but with higher accuracy, and, owing to the method of calculation adopted, with a decrease in the number of cards. The 'master pack' of Hollerith cards, for sines and cosines up to order 20, totals 492 cards, while the following advantages over the existing Beevers–Lipson strips are obtained: (*a*) the interval in the argument is 3° instead of 6°; (*b*) the values of the functions are entered to four figures to ensure certain 3-figure accuracy in the final result; (*c*) although cards are punched for amplitudes of 1, 10 and 100 only, the method of working enables any 3-figure amplitudes to be employed.

In practice, we find it convenient to duplicate each card about thirty times, but the number of *different* cards remains 492, and since sines and cosines are never handled simultaneously, the maximum number of different kinds of cards to be dealt with at any one time is 252. With this small number it becomes possible to devise simple systems of picking out the cards required by hand in the laboratory, without the assistance of trained operators or Hollerith sorting machines.

The cards are kept in a pigeon-hole system (details of which are a matter of individual choice) and the 492 pigeon-holes are divided into eight sets according as the cards are sines or cosines; positive or negative; and odd or even multiples of 3° (a particular card contains entries of the function for 3°, 9°, 15°, etc., or 6°, 12°, 18°, etc.; in this way, when circumstances do not justify 3° intervals in the calculations, only the even cards need be used). Each pigeon-hole contains about thirty identical cards.

The selection of the cards for a synthesis follows the same general lines as for the selection of Beevers–Lipson strips, with one important difference. Nine 'digiting cards' are laid out in order and numbered 1 to 9; a 3-figure amplitude (say, 359) is selected by picking one each of the appropriate 1, 10 and 100 cards, and placing them on the 9, 5 and 3 digiting cards respectively. This process is repeated until all the amplitudes required have been selected, and the nine packs of cards are then put together in order, and are ready to be checked and go through the tabulating machine (usually with other similar packs for other parts of the calculation, separated by spacing cards).

Avoidance of errors in hand-picking is largely a matter of the lay-out of the pigeon-hole system and the establishment of a suitable routine; but as complete freedom from error cannot be assumed, the odd and even cards, which are picked separately and should be identical as regards amplitude and order, are put through a comparing reproducer, which detects differences between the two sets.

In the tabulator, each entry on the cards is multiplied by the number of the adjacent digiting card before being incorporated in the appropriate total; it is for this reason that entries on the cards are made to four figures, so that the effect of rounding off the fifth place, even when multiplied by nine, cannot affect the accuracy of the third place.

The results of the tabulation (either actual electron densities or intermediate data according to the stage of the syntheses) may be printed on paper or punched on Hollerith cards (for filing or subsequent use), or both. To complete the work, the cards which have been used are sorted back into pigeon-hole order on a sorting machine.

The time taken for a synthesis depends upon the particular circumstances of each case, but the order of magnitude may be inferred from the following example. We evaluated the appropriate 3-dimensional section to locate one of the central (CH_2) carbon atoms in dibenzyl, using 3-figure values of the structure factors determined by Jeffrey[5]. The whole operation took two persons approximately ten hours, of which about half was spent in the laboratory selecting and preparing the cards, and half at the machines, comparing, tabulating and re-sorting. There was an appreciable loss of time on account of the improvised nature of our pigeon-hole system and of our inexperience, so that we think with practice it should be possible to reduce the time for a similar computation by several hours.

Nevertheless, it will be clear that to determine, by our method, the electron density throughout, say, one quarter of a unit cell, involving perhaps sixty 3-dimensional sections, would be a very lengthy process. We wish, therefore, to emphasize that it

has not been our aim to provide for comprehensive syntheses of this type, which are not necessary in dealing with the comparatively small molecules in which we are interested, and which at the present time can be carried out efficiently only by a centralized computing service, to which our method should be regarded as complementary. Our procedure, which we consider to be sufficiently simple to be within the reach of any laboratory engaged on accurate structure analysis, is particularly adapted to the evaluation of electron densities with good accuracy over limited areas; for example, in regions where atoms are indicated by 'trial and error' or other preliminary investigations. The methods of selecting the cards and of tabulating confer a flexibility which enables this to be done with equal ease for any part of the unit cell, and by restricting calculations to regions which contain details of interest, it becomes feasible to use the Hollerith method not only for final syntheses but also for some, at least, of the preceding ones too.

We shall be glad to give working details of this method to anyone who is interested.

We wish to thank Mr. W. McL. Wishart and Mr. J. L. Ineson of the Central Electricity Board for placing Hollerith machines at our disposal, Messrs. Bartindale, Cruickshank, Gillot, Nyburg and Stadler for help in carrying out trials, and Mr. J. Grant of the British Tabulating Machine Co. for his helpful interest.

E. G. Cox
L. Gross
G. A. Jeffrey

Chemistry Department,
University, Leeds.
Jan. 31.

[1] For example, Robertson, J. M., *Phil. Mag.*, **21**, 176 (1936). Lipson, H., and Beevers, C. A., *Proc. Phys. Soc.*, **48**, 772 (1936).
[2] Cf. Booth, A. D., *Nature*, **156**, 51 (1945).
[3] For example, Comrie, L. J., in discussion on paper by Beevers, *Proc. Phys. Soc.*, **51**, 660 (1939).
[4] *J. Chem. Phys.*, **14**, 648 (1946).
[5] *Proc. Roy. Soc.*, A, **188**, 222 (1947).

Orientation of Fibrils in Natural Membranes

In recent years, several studies of the orientation of chitin and protein chains in the insect cuticle[1,2] and of cellulose chains in plant cell walls[3] have appeared. Between 1938 and 1940, X-ray, optical and chemical studies of the cuticle of annelids and nematodes were made by one of us (L. E. R. P.) with the idea of obtaining information about the structure of other types of natural membranes. The cuticles of these animals are largely composed of fibrils of a protein belonging to the collagen group, distributed with their long axes in the plane of the cuticle and in two preferred orientations with respect to the long axis of the body. In annelids, such as *Aphrodite* and *Lumbricus*, the fibrils cross at *c.* 90°, and each set makes an angle of *c.* 45° with the long axis. In *Ascaris*, the two sets make an angle of *c.* 135° with each other and of *c.* 70° with the long axis. An arrangement of this kind may be mechanically advantageous, since the resulting membrane is capable of anisometric extension, though the individual fibrils are inextensible.

It has been suggested[4] that the cellulose chains in plant cell walls are deposited in sheets, alternately oriented in one or other of two preferred directions, and that this orientation depends on control exercised by the protoplasmic surface of the cell. The preferred orientation of fibrils in membranes bounding grossly macroscopic organisms, such as round and bristle worms, where the cuticle is formed by a hypodermis composed of millions of cells, would seem to require a high degree of co-ordination of the activities of these cells, if orientation depends on the protoplasmic surface beneath the cuticle. The mechanical aptness of fibrillar orientation in the cuticle, however, invites an alternative hypothesis: that shear and/or tension forces acting during secretion may be responsible for the observed orientation.

In the filamentous alga *Chætomorpha linum*, it has been shown[5] that both longitudinally and transversely oriented cellulose chains are present in each of the microscopically visible lamellæ of the cell wall. A macroscopic system in some respects similar has been studied in the cocoon of the chrysomelid beetle *Donacia*. Although first deposited as a viscid mass surrounding the larva[6], this barrel-shaped, chitinous cocoon afterwards hardens, becomes laminated, and exhibits positive birefringence with respect to the shorter diameter after freeing from sclerotin. The organisation of the cocoon cannot in this case be due to the intervention of a protoplasmic surface. Recently, one of us (M. M. S.) has shown that the thinnest single laminæ which can be separated from the *Donacia* cocoon are mosaics of birefringent and isotropic regions. If the extinction directions in a number of laminæ are plotted against frequency in a polar diagram, it is found that the chitin chains are oriented predominantly at 45° and 90° to the long axis of the cocoon.

These observations on different types of macroscopic cuticular membranes suggest that (*a*) 'crossed fibrillar'[3] orientation can occur at the surface of cylindrical units of a very different order of size from that of single cells; (*b*) preferred orientation of fibrils with respect to the morphological axes of the unit may be due to mechanical forces acting during deposition; (*c*) contact with a protoplasmic surface is not essential for the formation of a laminated membrane with two preferred orientations of chitin chains; (*d*) preferred orientation in two directions may occur within a single microscopic lamina of a multilaminate, macroscopic membrane.

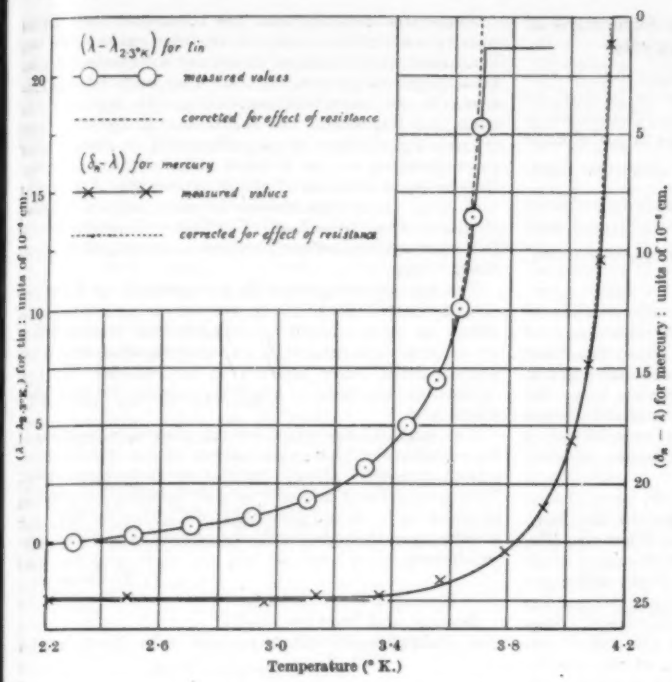
L. E. R. Picken
M. G. M. Pryor
M. M. Swann

Zoological Laboratory,
Cambridge.
Feb. 6.

[1] Fraenkel and Rudall, *Proc. Roy. Soc.*, B, **129**, 1 (1940).
[2] Fraenkel and Rudall, *Proc. Roy. Soc.*, B, **134**, 111 (1947).
[3] Preston, *Proc. Roy. Soc.*, B, **133**, 327 (1945).
[4] Preston and Astbury, *Proc. Roy. Soc.*, B, **122**, 76 (1937).
[5] Nicolai and Frey-Wyssling, *Protoplasma*, **30**, 403 (1938).
[6] Böving, "Natural History of the Larvæ of Donaciinæ" (Leipsig, 1910).

A New Method for Determining the Penetration Depth in Superconductors

It is a well-known property of high-frequency electrical transmission lines[1] operating in the normal mode that the velocity of propagation of a wave along the line is given by the equation $v = 1/\sqrt{LC}$, where L and C are the inductance and capacitance per unit length. But whereas for all frequencies used in practice the value of C is simply the electrostatic



using the parallel wire resonator described previously[3], that a change in resonant frequency occurred when superconductivity was destroyed by a magnetic field. Clearly there must be an alteration in the velocity of propagation, which is associated with a difference in the values of δ for the superconducting and normal states. This phenomenon may be used in certain circumstances to measure variations of λ with temperature; but unfortunately there seems to be little hope at present of using it for an absolute determination of λ, since a detailed investigation, to be published elsewhere, has verified the suggestion of H. London[4] that most metals at very low temperatures behave anomalously owing to the very long mean free paths of the electrons. Consequently, it is not possible to calculate the value of δ_n in the normal state from a knowledge of the skin resistance. If, however, as in the case of tin, the normal skin resistance, and hence presumably δ_n, is constant within 1 per cent between 4° K. and zero, measurements at various temperatures of the resonant frequency change which occurs when the magnetic field is applied enable the variation of λ with temperature to be studied. This variation is shown in the diagram, from which it may be seen that the method is capable of an accuracy of about 1 per cent.

The present determination was made without any refinement of the apparatus beyond that required by the resistance measurements already quoted, and the estimated probable error is $\pm 0{\cdot}2 \times 10^{-6}$ cm. Just below the transition temperature, it is necessary to apply a small correction for the influence of the radio-frequency resistance on the depth of penetration. The theory of this correction will be discussed in a more detailed account of the experiments to be published elsewhere.

On the same graph is shown the variation of the difference between δ_n and λ for mercury, but since here the normal skin resistance, and hence probably δ_n, varies with temperature, the interpretation of the curve is more difficult. It may be said, however, that this curve does not exhibit any gross divergences from the more direct determinations of λ [5]. Preliminary (unpublished) measurements on tin by the same authors show qualitative agreement with the results of the present method.

In conclusion, I should like to express my thanks to Dr. M. Désirant for his help in carrying out these experiments.

A. B. Pippard

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Feb. 11.

capacity between the conductors, the inductance must be considered as the sum of the two quantities, usually referred to as the internal and external inductances. The latter, $L_{ext.}$, is the value that would be assumed by the inductance if all the current were to flow on the surface, and the internal inductance, $L_{int.}$, represents a correction, very small at high frequencies, due to the finite penetration of the current into the body of the conductors. If the internal inductance be neglected, as indeed is common, the velocity is found to be in general the velocity of propagation of a plane unbounded wave in the dielectric medium surrounding the transmission line. The effect of the internal inductance is to alter the velocity by a factor $(1 - L_{int.}/2L_{ext.})$.

For the special case of the parallel-wire transmission line, formulæ have been developed for the capacitance and external inductance of the line; in order to take into account the internal inductance, the simplest procedure is to calculate C from the actual dimensions of the line, but for the calculation of L to imagine the radii of the conductors to be reduced by a quantity δ, which represents the effective skin-depth of the current. It is easy to show that for a normal metal obeying the classical conduction equation $J = \sigma E$, δ takes a value equal to one half of the skin-depth as usually defined, that is, $\delta = \frac{1}{2\sqrt{2\pi\omega\sigma}}$, while for a superconductor obeying the equations of F. and H. London[2], δ is the same as the penetration depth, λ.

Now it is very difficult to measure the velocity of propagation sufficiently accurately to determine δ directly, but it is a far easier problem to measure with considerable accuracy small changes in the velocity due to variations of δ. It was observed during experiments on the radio-frequency resistance of superconductors at a wave-length of 25 cm.,

[1] See, for example, Jackson, Willis, "High Frequency Transmission Lines" (Methuen).
[2] London, F., and London, H., *Physica*, **2**, 341 (1935).
[3] Pippard, *Nature*, **158**, 234 (1946).
[4] London, H., *Proc. Roy. Soc.*, A, **176**, 522 (1940).
[5] Shoenberg, *Proc. Roy. Soc.*, A, **175**, 49 (1940). Désirant and Shoenberg, *Nature*, **159**, 201 (1947).

A New Method of Studying the Structure of Alloys by Magnetic Analysis

In testing metal wires for ferromagnetism in this laboratory, a cathode ray oscilloscope is used to exhibit either of two curves, one showing the variation with the external field strength H of the rate of change of magnetic intensity $\frac{dJ}{dt}$ in a single wire, the other the hysteresis loop J v. H. By a simple calculation the values of the former can be transformed into values of $\frac{dJ}{dH}$, that is, the differential susceptibility, K_d.

With wires of homogeneous material, both traces appear as smooth curves throughout the range of applied field strengths (Figs. 1 and 2). The differential curve shows a pronounced peak or bulge corresponding to the steepest part of the hysteresis loop, the general form of the curve being very similar to those given by Bozorth and Dillinger in their classical work on the volume concerned in a Barkhausen discontinuity.

A number of 'tested' wires, however, have shown pronounced irregularities in this curve in the form of subsidiary peaks which in extreme cases rise like needles to a height exceeding that of the main peak of the curve (Fig. 3; the largest peak, although visible on the negative, was insufficiently defined for adequate reproduction, and has, therefore, been drawn in to the same height as on the negative). They may occur singly or in clusters, which usually contain at least one main peak, and several such clusters may be exhibited on one curve. With an applied field in excess of the value at the main peak, these irregularities are spaced over the portion of the curve corresponding to the section of the hysteresis loop between the knee of the demagnetization quadrant and the steepest part; and it has been found that the values of H at which they occur remain constant as the applied field is reduced, although the optical effect is that of movement towards the main peak, since the latter occurs at lower values of H with low applied field strengths. The more pronounced of these irregularities are easily observed as step discontinuities in the hysteresis loop (Fig. 4).

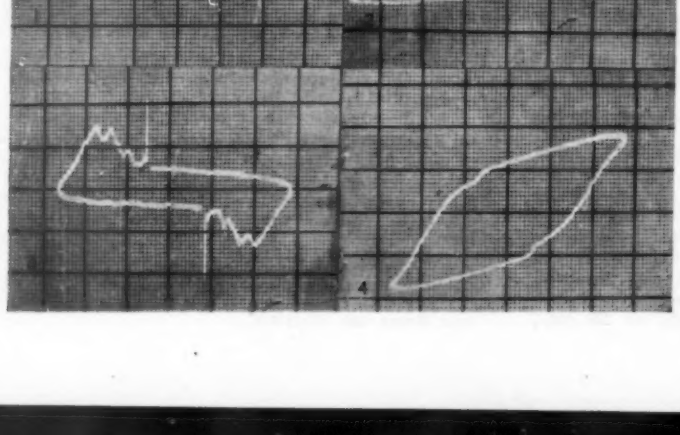
Since the irregularities are found to vary in intensity as different points on the same wire are examined, it is obvious that they are caused by inhomogeneities of structure such as may be due, for example, to imperfect annealing. It is considered that they represent 180° reversals of demagnetized domain orientation of magnetization at values of H corresponding to the critical value H_c for different ferritic combinations of the constituents of the wire, and that their appearance in any material would indicate the presence of alloy micro-structures (whether agglomerates or transition zones) of differing coercivities.

Further investigation is proceeding, and it has already been found that in certain circumstances the effect can be produced by suitable heat treatment of an otherwise normal wire at temperatures which are known from other sources to be suitable for precipitation processes at grain boundaries for the alloy examined.

The method described would, therefore, appear to be suitable for the examination of the structure of inhomogeneous alloys exhibiting ferromagnetism. This preliminary account is put forward as possibly of interest to other investigators, since, so far as is known, no other observations of this type have been published.

P. T. Hobson

Research Department,
Boosey and Hawkes, Ltd.,
Edgware, Middlesex.
Feb. 3.



Radioactivity of Radioaluminium

In a recent letter in the *Physical Review* by Sachs[1] and one in *Nature* by Allan and Clavier[2], and in several papers during the war years, reference is made to the disintegration of radioaluminium according to the reaction

$$^{28}Al \rightarrow {}^{28}Si + e^-.$$

The β-particle spectrum has been measured by Cork, Richardson and Kurie[3], who find a maximum energy of 3·3 MeV., and by Eklund and Hole[4], who find a maximum of 2·98 (± 0·18) MeV. The shape of the spectrum suggests a simple transition. γ-Radiation has been observed and estimated as 1·8 MeV. by Itoh[5], and 2·05 (±0·15) MeV. by Eklund and Hole[4].

A paper by Watase[6] in 1941 described coincidence experiments which showed that all β-particles from radioaluminium were followed by the same amount of γ-radiation. There was no evidence for γ-rays in cascade.

Absorption and coincidence experiments were carried out by me in 1939[7,8], which are in full accord with the Japanese work and showed that the β-spectrum was substantially simple. The maximum energy of the β-particle spectrum was estimated as 3·10 (±0·10) MeV., and no change in β–γ coincidence-rate per β-particle was observed up to absorption thicknesses of 480 mgm. per sq. cm. of aluminium. No γ–γ coincidences

could be detected, and the β–γ coincidence-rate per γ quanta indicated that all γ-quanta were correlated with the main β-particle spectrum. It is therefore certain that in most aluminium disintegrations a simple β-particle spectrum of maximum energy about 3 MeV. is followed by a single γ-quantum. The coincidence experiment gave a net efficiency of detection of the γ-quanta corresponding to an energy of 2·15 MeV., in rough agreement with the estimates given above.

Accepting the energies given by Eklund and Hole[4], the disintegration energy of radioaluminium is 5·03 (± 0·23) MeV., and not a value of about 3 MeV. as given by Mattauch and other investigators[1,9,10].

J. V. Dunworth

Cavendish Laboratory,
Cambridge.
Jan. 31.

[1] Sachs, *Phys. Rev.*, **70**, 567 (1946).
[2] Allan and Clavier, *Nature*, **158**, 832 (1946).
[3] Cork, Richardson and Kurie, *Phys. Rev.*, **49**, 208 (1936).
[4] Eklund and Hole, *Ark. Mat. Ast. Phys.*, **29A**, No. 26 (1943).
[5] Ikoh, *Proc. Phys. Math. Soc. Jap.*, **23**, 605 (1941).
[6] Watase, *Proc. Phys. Math. Soc. Jap.*, **23**, 618 (1941).
[7] Dunworth, *Rev. Sci. Instr.*, **11**, 167 (1940).
[8] Dunworth, Ph.D. thesis, Cambridge (1941).
[9] Mattauch, "Kernphysikalische Tabellen" (Springer, 1942).
[10] Saha and Saha, *Trans. Nat. Inst. Sci. India*, **2**, 193 (1946).

Occurrence of a Monotropic Transformation in Trinitroanisole

A striking example of the persistence of the metastable crystalline modification of a substance in the absence of nuclei of the stable form has recently been experienced in this Laboratory.

During the seven months prior to January 18 of this year, all efforts to prepare pure trinitroanisole here, either from picryl chloride or from dinitroanisole, consistently resulted in producing a substance melting sharply at 57·5° C. as compared with the figure of 68° C. normally expected for trinitroanisole. Ultimate analysis gave the results to be expected for this material, and somewhat elaborate chromatographic treatments served to confirm its high state of purity.

A sample of normal trinitroanisole melting at 68° C. was introduced into this Laboratory on January 18, since when all fresh local preparations of the substance have melted at 68° C. Moreover, all material previously melting at 57·5° C. was almost immediately transformed to the more stable modification on exposure to the air of the laboratory.

β-Trinitroanisole was prepared afterwards by sealing small quantities of the stable α-form in glass tubes, which were then completely immersed in boiling water to destroy all crystalline form. After supercooling, crystallization was induced by means of loose pieces of glass rod originally introduced with the crystals. In this way, the β-form was usually produced, and could be preserved for some time in the metastable state. When such a tube was broken in a 'contaminated' atmosphere, transformation commenced almost immediately, even above the melting point of the β-form.

By inducing crystallization of the β-form at the centre of a supercooled film on a microscope slide, the transformation could be initiated at a corner of the film and observed through a polarizing microscope. The rate of transformation, as measured by the movement of the new crystal face across the film, became slower with rise of temperature, thus confirming the monotropic nature of the change.

There is an interesting historical aspect of this observation. In 1903 Holleman[1] expressed his astonishment at his failure to prepare trinitroanisole melting above 58° C. He sent a sample of his material to Hantzsch[2], who stated that when it was purified he obtained material of normal melting point. There seems no doubt now that Holleman's preparation consisted of the metastable form, and it is conceivable that when Hantzsch exposed it to the air of his own laboratory it would have been transformed without the necessity for further purification. In 1924 Van de Vliet[3], who is believed to have worked in the same laboratory as Holleman, published further evidence in support of a melting point of 58° C., having failed to obtain a higher figure. Evidently this is a case where the metastable form persisted for more than twenty years.

I wish to thank Dr. O. L. Brady, of University College, London, for his interest and suggestive comments in connexion with the transformation.

T. C. J. Ovenston

Naval Ordnance Inspection Laboratory,
Holton Heath,
Poole, Dorset.
Feb. 5.

[1] Holleman, *Rec. trav. Chim.*, **22**, 269 (1903).
[2] Hantzsch, *Ber.*, **39**, 3074 (1906).
[3] Van de Vliet, *Rec. trav. Chim.*, **43**, 621 (1924).

The Boron-Trifluoride Catalysed Reaction of Di-isobutene

The polymerization of isobutene and the dimerization of di-isobutene are both catalysed by Friedel–Crafts catalysts. Earlier work on these reactions has led to the conclusion that a third component, other than the Friedel–Crafts catalyst and the monomer, is necessary for an appreciable reaction-rate to occur; and it has been shown, in particular, that the rapid polymerization of isobutene in the gas phase, using boron trifluoride as catalyst, does not occur if these reactants are pure, but does occur if a trace of water is present[1].

We have now used high-vacuum technique to study the reaction of di-isobutene in the gas phase at room temperature with boron trifluoride as catalyst. The pressures of di-isobutene and of boron trifluoride were each of the order of 20 mm. Unpurified di-isobutene vapour reacts rapidly on mixing with boron trifluoride. (The reaction is observed by the fall in pressure.) Di-isobutene vapour, purified by several distillations *in vacuo* over freshly distilled sodium at 60° C., does not react on mixing with boron trifluoride.

Di-isobutene vapour, purified in this way, was mixed with boron trifluoride, and to this non-reacting mixture a small quantity (2–3 mm. pressure) of the vapour of some third component was added. In some cases the addition of the third component caused the di-isobutene to react rapidly. This occurred when the third component was water or acetone. In these experiments the boron trifluoride combined instantaneously with the added vapour of the third component in approximately equal molar quantities. The acetone was purified by distillation *in vacuo* over freshly distilled sodium.

In other cases, the addition of the third component did not produce a rapid reaction of the di-isobutene, and the boron trifluoride did not combine with the added vapour. Examples of this class which we have studied are oxygen, hydrogen sulphide and hydrogen chloride. In each of these cases, the final addition of water vapour to the non-reacting mixture produced rapid reaction.

The addition of ammonia vapour to the non-reacting catalyst-monomer mixture results in the instantaneous combination of the ammonia with the boron trifluoride, in approximately equal molar quantities, but has no effect upon the di-isobutene reaction. The subsequent addition of water vapour to this mixture produces the rapid reaction of di-isobutene.

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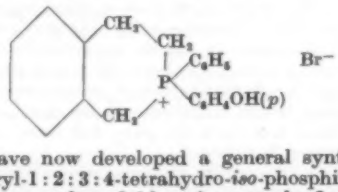
[1] Evans, A. G., Meadows and Polanyi, *Nature*, **158**, 94 (1946). See also Evans, A. G., Holden, Plesch, Polanyi, Skinner and Weinberger, *Nature*, **157**, 120 (1946). Evans, A. G., and Polanyi, *J. Chem. Soc.*, in the press. Plesch, Polanyi and Skinner, *J. Chem. Soc.*, in the press.

An Optically Active Quaternary Phosphonium Salt

OF organic derivatives of phosphorus (that is, containing C—P links), the only type which has hitherto been resolved into optically active forms is that represented by the general formula $R^1R^2R^3P \rightarrow X$, where R^1, R^2 and R^3 are different alkyl or aryl groups and X is either oxygen or sulphur: Meisenheimer *et al.*[1] have resolved tertiary phosphine oxides, for example, phenyl-benzyl-methyl-phosphine oxide, and Davies and Mann[2] have similarly resolved phenyl-*p*-carboxymethylphenyl-*n*-butyl-phosphine sulphide.



We have now developed a general synthesis of 2 : 2-diaryl-1 : 2 : 3 : 4-tetrahydro-*iso*-phosphinolinium salts. One member of this series, namely, 2-phenyl-2-*p*-hydroxyphenyl-1 : 2 : 3 : 4-tetrahydro-*iso*-phosphinolinium bromide (see formula), we have resolved through the *d*-camphor sulphonate and isolated in the optically pure state having $\alpha_D + 0{\cdot}34°$, $[M]_D + 32{\cdot}9°$. This bromide shows considerable optical stability and undergoes no perceptible racemization when boiled in alcoholic solution.

This, therefore, represents the first example of an optically active quaternary phosphonium salt, a compound which, in general structure, is closely related to 2-phenyl-2-*p*-chlorophenacyl-1 : 2 : 3 : 4-tetrahydro-*iso*-arsinolinium bromide, the resolution of which we have recently recorded[3].

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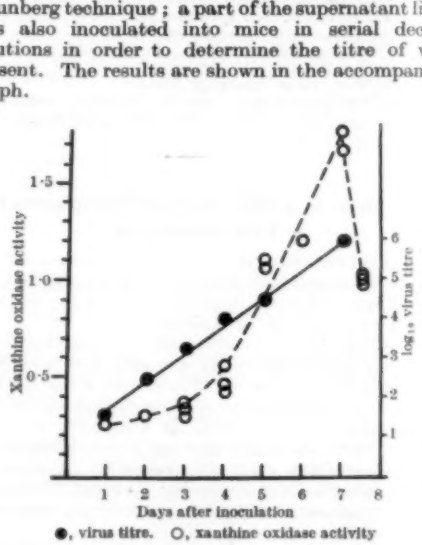
[1] *Ber.*, **44**, 356 (1911). *Ann.*, **449**, 224 (1926).
[2] *J. Chem. Soc.*, 276 (1944).
[3] *J. Chem. Soc.*, 550 (1943).

Xanthine Oxidase and Virus Growth

So far as is known, viruses appear to possess no enzyme activity; the virus particles, in order to multiply, must presumably utilize the enzyme-substrate reactions of the host cells, or else have a selective affinity for the products of host metabolism. It is thus possible that an investigation of the biochemical activities of tissues containing a growing virus might disclose an abnormality of enzyme action which would yield information upon the metabolic activities of the virus itself. With this object in view, preliminary studies have been carried out upon the xanthine oxidase content of the brains of mice with yellow fever encephalitis.

A group of mice were inoculated intracerebrally with 10^5 LD_{50} of the 17*D* strain of yellow fever virus. Each day after the inoculation a mouse was selected at random, the brain was removed, ground with 5 c.c. distilled water and centrifuged. The supernatant fluid was tested for xanthine oxidase activity by the Thunberg technique; a part of the supernatant liquid was also inoculated into mice in serial decimal dilutions in order to determine the titre of virus present. The results are shown in the accompanying graph.



●, virus titre. ○, xanthine oxidase activity

The titre of virus in the brain rises steadily to a maximum of 10^6 on the seventh day, when symptoms of encephalitis appear. Throughout this incubation period the amount of xanthine oxidase in the brain (expressed in arbitrary units) also rises. The normal level of enzyme activity in mouse brain lies between 0 and 0·2 in the units adopted; in the mouse brain infected with yellow fever virus, the activity rises to a value of 1·7 at the time of onset of symptoms. As paralysis increases the enzyme content falls, and reaches a value of 1 or less when the animal is moribund. Similar results were obtained with the neurotropic and Asibi strains of yellow fever virus, and with the virus of lymphocytic choriomeningitis.

The question naturally arises as to whether the observed increase of enzyme content in these virus infections is significant or purely a chance finding. As encephalitis develops, a round-cell infiltration of the brain appears, and it might be that these round-cells, presumably lymphocytes, attracted to the brain by an unknown stimulus, bring xanthine oxidase with them in an incidental manner. This point was investigated in two ways:

(*a*) Brains were removed at daily intervals during the incubation period. Each was divided into halves longitudinally; the xanthine oxidase activity of one half was determined while the other was fixed, sectioned and stained with hæmatoxylin and eosin. It was found that the xanthine oxidase activity had already considerably risen by the second day, whereas cellular infiltration did not appear until the third day and was not prominent until the fourth day after inoculation.

(*b*) Determinations were made of the desoxyribonuclease activity of normal and virus-containing mouse brains. No significant difference was found. This enzyme is present in large amounts in mouse lymphatic tissue; since the cellular infiltration is insufficient in amount to produce a detectable increase of desoxyribonuclease activity, it is not likely that it is responsible for producing the observed rise of xanthine oxidase activity, which at times amounts to ten times the normal value.

The evidence, therefore, does not support the view that xanthine oxidase is introduced into the brain by the accumulation of inflammatory cells, as it begins to increase in amount some considerable time before cellular infiltration appears. This being so, it is possible that the presence of the virus brings about in some way the accumulation of xanthine oxidase, perhaps by a selective affinity for it which is greater than that of the host tissues, and that the enzyme is an essential growth factor which is required for virus multiplication.

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The Premaxilla and the Ancestry of Man

In 1914 I had the privilege, thanks to the kindness of the late Prof. Fawcett, of studying the development of the human facial bones in his unique series of embryonic crania. In 1918, as a result of this investigation, I stated in my first publication on the "Ancestry of Man" that absence of the premaxilla on the human face was "a human specific character", and that from its very precocious ontogenetic development it might be presumed to be a very early phylogenetic acquirement. This statement received a certain amount of adverse criticism, but I repeated it and amplified it again in "Man's Place among the Mammals" in 1929.

At the time I did not realize that my findings were merely a repetition of those made by G. W. Callender in his forgotten paper of 1869. In that paper Callender had shown that in man the premaxilla is "shut off from the face by the nasal and incisor processes of the superior maxilla". Afterwards, Dr. E. H. Johnson, working in my department in the University of Melbourne, repeated the whole of the work on the development of the upper jaw in 1936. These results may be briefly summarized:

(1) Notwithstanding the numerous statements to the contrary, the suture between the maxilla and premaxilla is never present on the human face at any pre- or post-natal stage. This is so because

(2) in early embryonic life the maxilla of each side grows forwards over the *anlage* of the premaxillæ and, by meeting in the middle line of the upper jaw, buries them completely on their facial aspect.

(3) In this way those parts—the portion of the upper jaw bearing the incisor teeth and the narial margins—which in monkeys and apes are formed superficially from the premaxilla are, in man, constituted by the medially growing incisor and nasal processes of the maxilla.

(4) The division between the superficial maxilla and the buried premaxilla in man is marked, as Jarmer showed in 1922, by the interalveolar suture; for in man alone are the sockets for the incisor teeth formed from maxilla labially and premaxilla lingually.

This striking fact of the fundamental difference between man and any other of the existing Primates in the architecture of the upper jaw appears to have been completely overlooked in assigning the rank of 'hominid' or 'man-apes' to the Taungs and Sterkfontein skulls. *Australopithecus* and *Plesianthropus* show definite facial maxillary–premaxillary sutures in typical simian form, and *Paranthropus* fails to show it only because the individual is over the age at which it is obliterated and not at all because the condition is 'as in man'.

Whether the orthograde bipedal posture and the other attributes that have been claimed for these South African forms will ultimately be established is a question that only time and further discoveries can solve. But meanwhile it can be asserted with every possible assurance that all of them are apes, and that they throw no light whatever on the primate forms that were ancestral to *Homo*.

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Species of Sulphur Bacteria Associated with the Corrosion of Concrete

It has already been shown[1] that in the highly acidic end-products of corrosion of concrete sewers exposed to atmospheres containing hydrogen sulphide, there are present large numbers of a sulphuric acid-forming species of sulphur bacterium provisionally named *Thiobacillus concretivorus*. Further, it has been shown[2] that the typical corrosion process is a case of bacterial corrosion; it cannot proceed under sterile conditions and can only be carried to the acid stage through the activity of this organism. It is typical of this form of corrosion that the *p*H of the products falls continuously as the corrosion process becomes established. As the organism cannot exist at a higher *p*H than 6·5, its activity could not explain the initial stage of the process in which the *p*H of the fresh concrete surface (11–12) falls to 6·5 or less. It was then suggested that this preliminary drop in *p*H could be brought about either by purely chemical reactions or by the activity of further species of bacteria.

I have now isolated, from the corrosion products of concrete in the early stages of corrosion, two other groups of bacteria the activity of which explains this preliminary drop in *p*H.

The first group appears to be a homogeneous single species characterized as follows: the organisms are strictly autotrophic Gram-negative bacilli which rapidly oxidize thiosulphate to sulphate, polythionate and elemental sulphur, forming a pellicle of sulphur

and reducing the *p*H of the culture medium to 3·0–3·3. They grow in a hydrogen sulphide atmosphere, in culture media containing excess calcium carbonate, forming a pellicle of sulphur and reducing the *p*H to the same value as with thiosulphate. They oxidize elemental sulphur slowly with the formation of sulphate, but do not oxidize alkali sulphides. The range of *p*H over which they exist varies slightly from strain to strain. It is between the approximate limits of 3·5–8·5; but these depend to some extent on the *p*H of the corrosion products from which the strain is isolated. This group resembles in many respects the species *Thiobacillus thioparus* isolated by Nathansohn[3] and studied by Beijerinck[4] and Starkey[5,6,7].

The second group consists of a miscellaneous collection of species characterized by considerable variation in colony form and morphology, but they are all facultatively autotrophic and grow profusely on nutrient media. They slowly oxidize thiosulphate to polythionates and sulphate without the formation of elemental sulphur, and in fact show little evidence of growth in mineral media; the *p*H first rises and then slowly falls to the initial *p*H of the medium. They tolerate a wide range of *p*H (2·0–10·5), but the optimum for growth is between 7 and 10. They can exist in a hydrogen sulphide atmosphere with calcium carbonate in the culture medium, but will not grow with elemental sulphur or sulphides as the source of sulphur.

By the use of mineral media of appropriate *p*H and sulphur source, and by making tenfold dilutions of samples of the extract from corrosion products, it is possible to obtain an approximate count of the numbers present of each of the three groups of bacteria associated with the corrosion process. Such counts performed on corrosion products of varying *p*H are shown in the table.

Sample of corrosion product	*p*H of sample	Dilution of sample to show growth		
		Th. concretivorus	*Th. thioparus*-like group	Miscellaneous group
A	9·88	Nil	10^2	10^6
B	7·52	Nil	10^2	10^6
C	5·77	Nil	10^2	10^5
D	4·03	10^2	10^5	10^7
E	3·42	10^5	Nil	Nil
F	2·18	10^6	Nil	Nil

Each of the three groups predominates at different stages of the corrosion process, the miscellaneous group of facultative autotrophs in the initial stage (*p*H 11–9), the *Th. thioparus*-like species between *p*H 9 and *p*H 5, while *Th. concretivorus* alone is present during the final stage of free acid formation below *p*H 5.

Evidence concerning the formation of intermediate products has been obtained by the exposure of sterile material to a hydrogen sulphide atmosphere. It has been found that on sterile fresh concrete small amounts of thiosulphate and polythionate are formed, while elemental sulphur is produced on sterile samples of the acidic end-products of corrosion. The whole corrosion process may, therefore, be explained as follows: the exposed walls of new concrete sewers with an initial *p*H of 11–12, on exposure to an atmosphere containing hydrogen sulphide, are subject to a twofold chemical change. Normal carbonation lowers the *p*H to 8·4 (the *p*H of the carbonate–bicarbonate–carbon dioxide equilibrium), and fixation of hydrogen sulphide as thiosulphuric and polythionic acids further lowers the *p*H to about 7·5.

While these purely chemical changes are taking place, there first occurs bacterial proliferation of the miscellaneous group of slow thiosulphate oxidizers. The oxidation by this group of the sulphur acids formed chemically does little to assist the drop in *p*H and may actually retard it. As the *p*H drops below 9, the *Th. thioparus*-like group then multiply, and their oxidation of thiosulphate and polythionate to sulphur and sulphuric acid results in a rapid drop in *p*H. This continues until the *p*H falls below 5, when *Th. concretivorus*, first by oxidation of sulphur formed by the *Th. thioparus*-like group and later by oxidation of the sulphur formed chemically, produces high concentrations (1–5 per cent) of free sulphuric acid, and so brings about the final products of corrosion typical of the process.

The early stage prior to the development of the *Th. thioparus*-like group is the slowest, and the corrosion increases in rate with the proliferation, first of the *Th. thioparus*-like group and then the *Th. concretivorus* group.

While the primary corrosive agent is hydrogen sulphide, none of the groups of bacteria concerned can utilize sulphides directly for growth. It is through the intermediate production of thiosulphates, polythionates and sulphur, by chemical means, that the corrosion process proceeds.

The detailed description of these bacteria and their function will be dealt with elsewhere.

I wish to thank Mr. E. F. Borie, the chief engineer of sewerage, Melbourne and Metropolitan Board of Works, for permission to publish this communication.

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[1] Parker, C. D., *Aust. J. Exp. Biol. and Med. Sci.*, **23**, 81 (1945).
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[6] Starkey, R. L., *J. Gen. Physiol.*, **18**, 325 (1934).
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A Sensitive 'Cartesian Diver' Balance

In experimental cell physiology, the main difficulty often is how to obtain a reliable measure of the amount of protoplasm showing the biological (enzymatic, respiratory) activity studied. Dry weight[1] or nitrogen-content[2] of the whole object may be measured, but the measurement involves the death of the object. We use the 'reduced weight' of an object, namely, the buoyancy (usually negative) when suspended in water. The reduced weight of small objects was measured by Linderstrøm-Lang[3], but the cells were injured by the procedure. The present method permits the measurement of the reduced weight of small living objects, which are not damaged by the procedure and may thus be studied again and again.

The principle of the balance is that of the Cartesian diver[4]. An air bubble (about 0·1 μl.) makes the balance float in water. The air bubble with some water is enclosed in a chamber which opens to the surroundings through a long narrow capillary, so that pressure

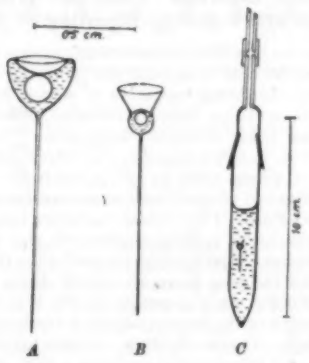
variations in the flotation vessel are transmitted to the air bubble, while loss of air by diffusion is restricted.

The change in equilibrium pressure (p_x) due to charging the balance with an unknown weight (reduced weight = $R.W_x$) is compared with the change (p_{st}) resulting from the charging with some known weight (reduced weight = $R.W_{st}$). $R.W_x$ is calculated from the equation

$$R.W_x = R.W_{st} \frac{1 - \frac{B}{B - p_x}}{1 - \frac{B}{B - p_{st}}},$$

B being the normal barometric pressure. B, p_x and p_{st} are expressed in centimetres of water.

Larger balances of glass (Fig. *A*, air volume 0·5–1·0 μl.) could be blown when heating was carried out with a glowing platinum wire. However, the smaller balances (0·04–0·15 μl.) extensively used (*B*) always turned out too heavy when made entirely of glass; so the scale is made of polystyrene (sp. gr. 1·05). Polystyrene is dissolved in benzene, and the solution is blown so as to form a bladder, which is made to adhere to the glass of the diver balance. After evaporation of the benzene, the bladder hardens, so that it can be separated into two halves using a razor. The lower half adheres as a scale to the diver balance.



As standards for the weighings we use small gold weights the reduced weights of which are determined in the gradient tube[5]. In routine work with the balance, however, it has been found more convenient to use small polystyrene weights, which are more easy to handle with a pipette. The whole equipment for measurements with the balance is the same as that used in the work with the Cartesian diver microrespirometer[6]. The flotation vessel with the balance is shown at *C*.

The present method has been worked out for the accurate study of large amœbæ (*Chaos chaos* L.), the volume of which in most cases ranges from 0·01 to 0·1 μl., corresponding to reduced weights of about 0·2–2 γ. Since the error of the method in routine work is ± 0·02–0·03 γ, and with very small balances only ± 0·01 γ, this means that even very tiny objects can be studied with a fairly good accuracy. A complete weighing, including both the standard and the object under investigation, occupies ½–¾ hour. So far, the method has been used to study how reduced weight decreases with starvation in amœbæ.

This method has been worked out in the Carlsberg Laboratory, and a full account of the method as well as of the studies (with Dr. H. Holter) on *Chaos chaos* will appear in the *Compt. rend. Lab. Carlsberg, Sér. Chim.*

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Distribution of the Total and Acetic Acid-Soluble Phosphate in Soil Profiles having Naturally Free and Impeded Drainage

In a reconnaissance soil survey of Aberdeenshire, a large and representative collection of soil profiles from a variety of geological parent material types has been made. Pairs of profiles differing in their degree of natural drainage—freely drained, and poorly drained (gleyed) soils—have been taken from a large number of arable fields over a variety of geological areas. Each particular pair of profiles presumably has had the same manurial treatment.

In the routine chemical analysis of these profiles, the percentages of total and acetic-soluble phosphate have been determined, and several facts relating to the phosphate status of these pairs of profiles have appeared.

The freely drained arable profiles have a medium brown crumb-structured *A* horizon; yellow or yellow-orange, mellow B_1 horizon; greyish-yellow, very indurated and compact B_2 horizon, which merges into the *C* horizon or parent material. The poorly drained soils have a grey-brown or brownish-grey cloddy *A* horizon, relatively low in organic matter, on a grey and brown mottled, cloddy gley *G* horizon.

It has been found that, in arable soils, when a freely drained and a poorly drained soil from the same field are examined: (1) the total phosphate content of the *A* horizon of the freely drained soil is greater than that of the poorly drained, and that the trend down the profile of the total phosphate generally shows a gradual decrease to the *C* horizon; (2) the total phosphate content of the poorly drained soil is at its highest value in the *A* horizon and tends to be lowest beneath the *A* horizon at the top of the gley horizon; beneath this it gradually rises to the *C* horizon; (3) the total phosphate in the *C* horizon of the freely drained soil is generally slightly higher than in the *C* horizon of the poorly drained soil; (4) the acetic-soluble phosphate in the freely drained soil is usually highest in the indurated B_2 horizon, in which the free silica and sesquioxides are also high; (5) the acetic-soluble phosphate in the poorly drained soil is generally highest in the gley horizon, where the total phosphate is lowest; (6) the rise in the acetic-soluble phosphate in the B_2 horizon of the freely drained soils is not connected with a corre-

sponding rise in the total phosphate content of this layer. The clay content and base-exchange capacity of the indurated horizon are lower than the horizons above and below it.

The content of organic matter in the freely drained soils decreases gradually down the profile, whereas in the poorly drained soils the *A* horizon tends to be lower than that of the freely drained and decreases sharply below this in the gley horizon. The *p*H of the poorly drained soils is generally somewhat higher than that of the freely drained soils. The silica sesquioxide ratios down the poorly drained profiles fluctuate in an erratic manner and alternate with a periodicity from high to low. It is suggested that it is due to the periodicity in fluctuation of the level of the ground-water of these soils.

The high total phosphate in the *A* horizon of the freely drained soil as compared with the parent material suggests that applied phosphate may be accumulated more readily in the unavailable form in the naturally freely drained soils.

The striking reduction in the amount of the total phosphate and the high, readily soluble phosphate in the *G* horizons of the poorly drained soils is possibly related to the reducing conditions. This points to a loss of phosphate in the ground-water from these soils.

These several trends in the phosphate status of soils of different drainage conditions are being investigated.

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Vernalization of Sugar Beet

In connexion with L. G. G. Warne's experiments on the vernalization of lettuce reported recently[1], we are able to confirm that the vernalization treatment given after radicle emergence had occurred has no effect on the bolting of sugar beets.

Field experiments were carried out last year near Tirlemont (Belgium) with 'Hilleshög' beets. Several sets of seeds were soaked for seventy-two hours, according to E. Larose and R. Vanderwalle[2], by which time germination had begun and radicles emerged here and there. After soaking, seven sets (III to IX) were held at 2–3° C. during periods varying from ten to seventy days. Two control sets (I and II) were not given the low-temperature treatment; (I) seeds were not soaked, (II) seeds were soaked during seventy-two hours. The nine sets were sown in the open on April 16 (six repetitions of two hundred beets for each set).

Compared with the control sets, the thirty to seventy days vernalized seeds emerged from the soil later, and the growth of the seedlings was seriously delayed during the first six weeks; the differences grew less apparent in June, and after the middle of July all the sets were showing the same development. The beets were harvested on October 24. As appears in the accompanying table, practically no bolting occurred, but there were many missing beets among the fifty, sixty and seventy days vernalized sets. Moreover, the low-temperature treatment showed no effect on the yield of the crop.

These observations confirm Dr. Warne's opinion as to the possibility of avoiding the undesirable influence of natural vernalization on sugar beets and other crop plants by the sowing of already germinated seeds. Further experiments would, of course, be necessary to determine, for each plant, the appropriate soaking conditions of the seeds and the timing of the vernalization treatments.

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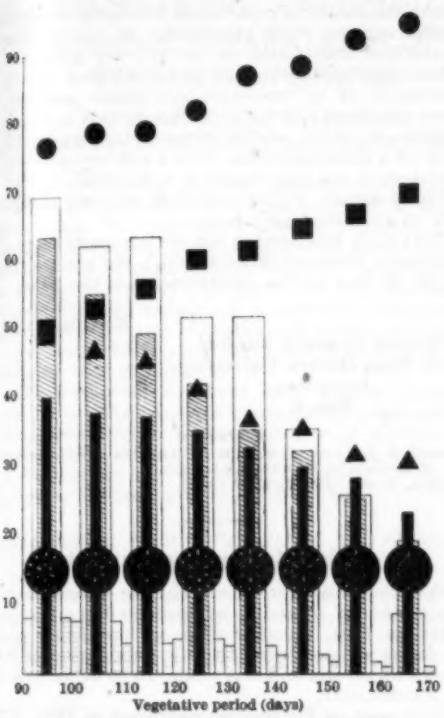
Correlation between Yield of Wheat and Temperature during Ripening of Grain

During the last five years investigations have been undertaken at this Institute for evolving a reliable method for obtaining varieties of wheat best suited to 'dry' as well as irrigated tracts, and also for determining their drought resistance. To achieve this purpose, a large number of exotic and Indian varieties of wheat (260 in all) have been grown on dry and irrigated plots of well-manured land at Delhi, Karnal and Pusa. The Indian varieties used in these experiments were representative of the important wheat-growing tracts of this country with their vegetative period ranging from 90 to 130 days, while the exotic varieties with a range of 90–170 days were representative of the important wheat belts of Canada, the U.S.S.R., Great Britain, Australia and other countries. All these varieties form a part of the large collection of wheat varieties maintained at this Institute.

Growth and harvest data, together with the dates of flowering and ripening of grain, were recorded. As the results appear to have some practical value, a brief preliminary report of the work is given here. It is intended to publish the full details of the work elsewhere. Some of the results are summarized in the accompanying diagram.

	Treatment	% missing beets	Bolters %	Roots		Sugar		Sugar		Leaves	
				Kgm.-ha.	±e	%	±e	Kgm.-ha.	±e	Kgm.-ha.	±e
1	Control	5	0	48,143	457	18·42	0·07	8872	103	38,420	1065
2	Soaked	5·5	0	49,011	488	18·56	0·10	9102	133	42,365	1100
3	Soaked, 10 days vernal.	5	0·08	47,320	493	18·67	0·10	8838	125	40,459	1407
4	" 20 " "	4·6	0	48,573	228	18·53	0·06	9002	51	42,562	685
5	" 30 " "	5·8	0	48,385	549	18·75	0·06	9072	96	41,887	855
6	" 40 " "	5·1	0	48,067	291	18·53	0·06	8908	66	42,421	1217
7	" 50 " "	13·7	0	46,218	482	18·47	0·11	8539	113	38,647	1312
8	" 60 " "	15·2	0·10	46,195	810	18·37	0·07	8491	165	40,836	1179
9	" 70 " "	9·2	0·18	47,893	465	18·55	0·09	8891	112	41,138	713



EFFECT OF TEMPERATURE ON YIELD OF WHEAT

, grain wt. per 10 plants (gm.)
, 1,000-grain wt. (gm.)
●, mean max. temp. of ripening period
■, „ min. „ „ „ „
▲, „ per cent humidity „
Hatched area, ripening period (days)
Dotted area (ear/tiller) × 10

The full range of the vegetative period is divided into eight classes with a class interval of ten days. The values of grain yield, ripening period, 1,000-kernel weight as well as ear/tiller ratio for each class have been derived by taking the mean of corresponding values for all varieties falling within a class. It will appear that there is a progressive fall in grain yield and 1,000-kernel weight from the early flowering varieties to the late flowering ones. The fall is especially noticeable in the last three classes. Varieties in late-flowering classes require fewer days for grain ripening compared to those in the early ones. Number of ears per plant does not increase in late varieties in spite of heavy tillering, and consequently ear/tiller ratio declines with lateness in flowering. Mean maximum and minimum temperatures as well as mean per cent humidity for each variety were calculated by summing up all the values of the respective climatic factor during the ripening period and dividing by the number of days of the ripening period. Means of all such values for varieties falling within a class have been entered in the diagram. The plumpness of the grain in different classes is indicated in the diagram on the black circular areas.

Total as well as partial correlation coefficients are all very highly significant, with the exception of one case where the partial correlation coefficient $r_{bc.a}$ is non-significant. It is worthy of note that the general trend of results remains the same for dry as well as irrigated crops. This indicates that there is a more pronounced effect of atmospheric drought at least during the ripening period, and that even if the level of moisture in the soil is raised by a late irrigation, its effect on the yield is relatively smaller than that of the adverse climatic factor, namely, the temperature prevailing during the ripening period. This is further supported by the study of indices of resistance to soil and atmospheric drought which are summarized in Table 2.

TABLE 1. TOTAL AND PARTIAL CORRELATION COEFFICIENTS SHOWING RELATIONSHIP BETWEEN (*a*) GRAIN YIELD, (*b*) 1,000-KERNEL WEIGHT, AND (*c*) MEAN MAXIMUM TEMPERATURE OF THE RIPENING PERIOD. *S* = significant at 1 per cent point; *s* = significant at 5 per cent point; *n* = not significant

Nature of crop	Total correlation coefficient	Partial correlation coefficient	Observed value of *t*
Irrigated	r_{ac} = −0·83 to −0·70	$r_{ac.b}$ = −0·60 to −0·27	39–7 *S*
	r_{ab} = 0·87 to 0·68	$r_{ab.c}$ = 0·58 to 0·56	87–19 *S*
	r_{bc} = −0·83 to −0·44	$r_{bc.a}$ = −0·47 to −0·07*n*	26–0·6 *S*
'Dry'	r_{ac} = −0·81 to −0·68	$r_{ac.b}$ = −0·51 to −0·15*s*	32–2 *S*
	r_{ab} = 0·88 to 0·64	$r_{ab.c}$ = 0·60 to 0·45	38–10 *S*
	r_{bc} = −0·89 to −0·54	$r_{bc.a}$ = −0·62 to −0·18	40–3 *S*

TABLE 2. RESISTANCE INDICES

Vegetative period (days)	100	110	120	130	140	150	160	170
Index of resistance to:								
Soil drought	0·56	0·45	0·60	0·56	0·47	0·45	0·47	0·53
Atmospheric drought	1·00	0·94	0·94	0·75	0·67	0·48	0·39	0·16

The index of resistance to soil drought was calculated by dividing the yield of a variety grown on dry land by the corresponding yield of the same variety grown on irrigated land in the same year and in the same locality. This index does not show any significant difference in different flowering classes. The index for resistance to atmospheric drought, on the other hand, which is obtained by dividing individual yields of varieties in each class by the mean yield of the earliest class, shows a progressive decline with lateness in flowering.

Although yield in wheat and other cereals has been correlated with different growth characters, such as 1,000-kernel weight, plumpness, weight of grain per spike, time of flowering, etc.[1,2,4,5,7,9], there is very little experimental evidence to show the effect of temperature on yield. So far as I am aware, Waldron[8] is the only one who has found experimentally a high negative correlation between yield of wheat varieties and the mean maximum temperature of July. It has recently been shown in this laboratory[6] that high temperature during the ripening period of late varieties accelerates the rate of cell division in the developing grain. In late varieties the rate of loss of water from the developing grain is also considerably greater. This shortening of the ripening period appears to be detrimental to processes involved in grain filling, as demonstrated by the progressively falling 1,000-kernel weight and the shrivelled nature of grain resulting in low yield.

This work is an experimental confirmation of the observation, made by Howard[3], that in India early wheats possess an advantage in yield over late ones by virtue of their capacity to avoid high temperatures. It also places the empirical method of selecting wheat

varieties so far practised in India on a scientific basis, showing that the selection should be on the correlation of yield and temperature during the ripening period.

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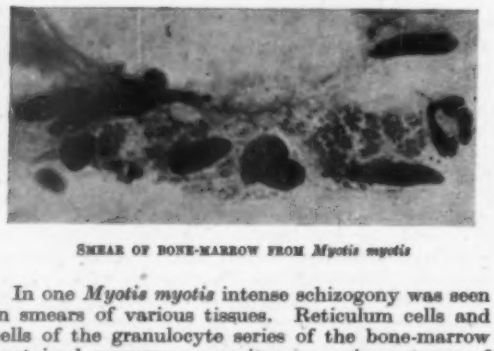
A Hæmosporidian of Bats

DURING the autumn of 1946 a number of bats belonging to ten species were examined for malaria parasites. These included: 39 *Rhinolophus ferrum-equinum*, 18 *Rhinopoma microphyllum*, 5 *Asellia tridens*, 13 *Taphozous nudiventris*, 57 *Myotis myotis*, 18 *Myotis daubentonii*, 17 *Myotis nattereri*, 78 *Pipistrellus kuhlii*, 45 *Miniopterus schreibersii* and 9 *Rousettus ægyptiacus*.

In 10 *Myotis myotis*, 3 *Myotis nattereri* and 35 *Miniopterus schreibersii*, red cells were found to harbour pigmented parasites. All the forms seen were diagnosed as gametocytes in various stages of development. The fully developed gametocyte is round and fills the whole of the parasitized red cell. The rate of infestation varied between single gametocytes in a thick drop up to two or three gametocytes per microscopic field in a thin film. Exflagellation of the microgametocyte was obtained in the wet chamber.

So far, no schizogonic cycle has been found in red blood cells even in splenectomized animals.



SMEAR OF BONE-MARROW FROM *Myotis myotis*

In one *Myotis myotis* intense schizogony was seen in smears of various tissues. Reticulum cells and cells of the granulocyte series of the bone-marrow contained numerous parasites in various stages of schizogony; in tissue smears free schizonts were also found. Wandering and fixed macrophages of the lung, kidney and liver were parasitized to a lesser degree. In one *Myotis nattereri* similar schizogonic forms were also found free in smears of the liver and kidney.

The schizogonic cycle in the tissues resembles in many respects that of *Hæmoproteus columbæ* as described by Aragão.

Myotis myotis, *Myotis nattereri* and *Miniopterus schreibersii* were heavily infested with pupiparous flies of the family Nycteribiidæ belonging to various species not yet fully identified. In one of these, sporozoites were found in the salivary glands.

Investigations up to now do not warrant any final conclusion as to the exact systematic position of these parasites. So far as we know, this is the first instance in which prolific extra-erythrocytic schizogony of a Hæmosporidian with a pigment-producing gametocyte has been found in a mammal.

Fuller details on the evolution of these parasites will be published elsewhere.

This work was carried out with a grant from the Wellcome Research Foundation. We are indebted to Dr. M. Dor for the identification of the bats.

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A Sandfly Described in 1691

WE have discovered recently the existence of a description of a sandfly by Phillipo Bonanni[1] published in 1691, together with an interesting plate. So far as we are aware, there is no mention of it in recent literature, and it is unknown to other workers on *Phlebotomus*.

Larrousse[2], in his treatise published in 1921, gives the earliest description of a *Phlebotomus* known to him then as being that of Scopoli[3] in 1786, and since Larrousse's monograph no earlier record seems to have been mentioned. Bonanni's description is of a general character, and he considers his sandfly to be a species of mosquito, which he calls *Sarapico*: "Culex minimus aculeatus Sarapico". He distinctly mentions its nocturnal and blood-sucking habits: "Avidissimus humani sanguinis noctu præcipuse venatur sine sonó", and appears to be surprised at the ferocity of the bite which this minute creature is capable of with its short proboscis.

We have not verified its systematic position as yet, but hope to attempt to do so in the near future. As there is no figure of the buccal armature and genital organs, and also on account of recently accepted taxonomic characters, it will prove difficult to relate it to one of the recently described species.

It should be mentioned that Bonanni directs attention to another insect which was sometimes captured together with his sandflies. It appears from the description and figure to be a species of *Pericoma*, a genus closely allied to *Phlebotomus*.

A detailed communication is to appear elsewhere.

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QUANTITATIVE CHROMATOGRAPHIC SEPARATIONS OF SYNTHETIC PEPTIDES

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THE following chromatographic separations of simple peptides have been reported in the last few years: fractionation of arginyl peptides on acid earths[1], partition chromatography of acetyl peptides on columns of silica gel[2], partition of free peptides on columns of starch[3], partition on two-dimensional paper chromatograms of a partial hydrolysate of gramicidin *S*[4] and of peptides of urine[5], and separations of synthetic peptides on columns of carbon by displacement analysis[6].

We now wish to report some simple chromatographic methods capable of separating quantitatively and specifically a complex mixture of peptides and amino-acids into different groups; the separation of each group into its constituents can be realized by paper chromatography or otherwise.

Adsorption of Neutral Peptides on Acid Alumina in 10 per cent Formaldehyde[7,12]

The following table contains the measurements of Dunn and Loshakoff[8] of the apparent acid dissociation constant (pKa') of neutral amino-acids and peptides in water and 9 per cent formaldehyde.

TABLE 1

Amino-acid	pKa' Water	pKa' 9% Formaldehyde	Peptide	pKa' Water	pKa' 9% Formaldehyde
Alanine	9·68	6·96	Glycyl-glycine	8·13	4·27
Valine	9·64	7·47	Di-glycyl-glycine	8·0	4·24
Norleucine	9·77	7·10	Glycyl-leucine	—	4·40
Phenylalanine	9·12	6·80	Alanyl-glycine	7·75	5·52
Glycine	9·60	5·92	Leucyl-glycine	—	5·57
Serine	9·15	5·63	Leucyl-tyrosine	—	5·07

Schramm and Primosigh[9] utilized the more acid pKa' of glycine and serine in 10 per cent formaldehyde to separate them from the other neutral amino-acids; glycine and serine are quantitatively adsorbed on acid alumina (Wieland[10]) and were eluted with alkali. Later they showed that threonine and cysteine are also adsorbed on alumina in 10 per cent formaldehyde[11].

We have applied the same principle to neutral peptides and found that they are all quantitatively adsorbed on acid alumina; they may be eluted quantitatively by hot water which dissociates the peptide-formaldehyde complex. β-Alanine, which has an $—NH_2$ group on a primary carbon like glycine, is also adsorbed quantitatively on acid alumina and may so be separated from α-alanine. Table 2 shows the results of some separations of binary mixtures of amino-acids and peptides.

TABLE 2. SEPARATIONS OF BINARY MIXTURES OF AMINO-ACIDS AND PEPTIDES IN 10 PER CENT FORMALDEHYDE

Non-adsorbed amino-acids	% in filtrate (i)	(ii)	Adsorbed substances	% in eluate (i)	(ii)
Alanine	99·4		Alanyl-phenylalanine	101·3	100
Alanine	99		Leucyl-glycine	100·5	
Alanine	100	96·4	β-Alanine	99·2	
Leucine	100	101·6	Glycyl-leucine	99	
Leucine	100·7		Leucyl-tyrosine	101·2	
Tyrosine	99·2	99	Alanyl-glycine	101·5	
Tryptophane	98		Alanyl-glycine	100·5	

(i), Nitrogen determinations by micro-Kjeldahl; (ii), determinations by known specific methods.

10 gm. of acid alumina[10] are washed in a column of 10 mm. diameter with 300 ml. of water; the *p*H of the last drop of effluent must be about 4·8–4·9 or else separations are not quantitative. After filtering on the column the solution of about 10 mgm. of the mixture of substances in 5 ml. of 10 per cent formaldehyde (*p*H 8·5), one washes the amino-acids into the filtrate with 50 ml. of 10 per cent formaldehyde (*p*H 8·5). Elution of the peptides is obtained by washing the column with 100 ml. of hot water (~90°).

Adsorption of Glycyl-peptides on Acid Alumina in 1 per cent Formaldehyde[12]

Table 1 shows that glycyl-peptides ($H_2N–CH_2–CONH–CHR–COOH$) have a more acid pKa' in 9 per cent formaldehyde than other (alanyl-, leucyl-, etc.) peptides. We have found that in 1 per cent formaldehyde glycyl-peptides are already sufficiently acid to be adsorbed quantitatively on acid alumina, whereas other peptides pass through the column, not being adsorbed. Elution of the glycyl-peptides is easily obtained by washing the column with hot water. The amino-acids glycine, serine, threonine, cysteine and β-alanine, which are adsorbed from 10 per cent formaldehyde solution, are not adsorbed from 1 per cent formaldehyde solution. Table 3 shows some separations of binary mixtures.

TABLE 3. SEPARATIONS OF BINARY MIXTURES OF AMINO-ACIDS AND PEPTIDES IN 1 PER CENT FORMALDEHYDE

Non-adsorbed substance	% in filtrate (i)	(ii)	Adsorbed peptide	% in eluate (i)	(ii)
Alanyl-leucine	102		Glycyl-leucine	98·3	99·2
Alanyl-leucine	100		Glycyl-tryptophane	98	100
Leucyl-glycine	100·7		Glycyl-leucine	98·6	
Leucyl-glycine	100		Glycyl-tryptophane	100·5	
Glycocolle	99·6	103	Glycyl-glycine	101·3	
Serine	97·6		Glycyl-tyrosine	100	93

(i), Nitrogen determinations by micro-Kjeldahl; (ii), specific determinations by known methods.

The optimum *p*H for separations in 1 per cent formaldehyde is 3·5 for effluent wash-water; acid alumina prepared according to Wieland[10] can be utilized as it is; the mixture of peptides (10–20 mgm.) dissolved in 5 ml. 1 per cent formaldehyde (*p*H 3·5) is poured on a column of 5 gm. acid alumina (10 mm. diameter); by washing with 50 ml. of 1 per cent formaldehyde, *p*H 3·5, the non-adsorbed substances are washed into the filtrate. Elution of adsorbed glycyl-peptides is obtained with 100 ml. hot water (~90°).

We suppose that seryl-, threonyl-, cysteyl- and β-alanyl-peptides will behave like the glycyl-peptides.

Adsorption of Aromatic Neutral Peptides on Carbon

Wachtel and Cassidy[13], Tiselius[6], Schramm and Primosigh[9] have studied adsorption of amino-acids on carbon columns, and have observed that the aromatic amino-acids (phenylalanine, tyrosine, tryptophane) are firmly bound. Elution of the adsorbed amino-acids is often difficult and seldom exceeds 85 per cent.

We have found that carbon columns retain quantitatively neutral peptides containing aromatic amino-acids; other neutral peptides containing only aliphatic amino-acids are not adsorbed. Elution is possible with water saturated with ethyl acetate[6,13]; yields attain 95 per cent if the carbon ('Activit *5OXP*'[14]) is first purified by boiling in 20 per cent

acetic acid and then treated with ephedrin[8]. 1 gm. of 'Activit' can adsorb about 30–50 mgm. of aromatic dipeptides. Table 4 shows some typical separations.

TABLE 4. SEPARATIONS OF BINARY MIXTURES OF ALIPHATIC AND AROMATIC PEPTIDES ON CARBON

Non-adsorbed aliphatic peptides	% in filtrate (i)	Adsorbed aromatic peptides	% in eluate (i)	(ii)
Leucyl-glycine	100·8	Leucyl-tyrosine	96·8	100
Glycyl-leucine	98·3	Glycyl-tyrosine	99·8	100
Alanyl-glycine	99·8	Alanyl-phenylalanine	100·4	99·1

(i), Nitrogen determinations by micro-Kjeldahl; (ii), specific determinations by known colorimetric methods.

0·5 gm. of 'Activit *5OXP*' is boiled for 5 min. with 4 ml. of 20 per cent acetic acid, filtered, washed with 15ml. hot water, then treated in a beaker with 10 ml. water containing 2 mgm. of ephedrine; after shaking for 10 min. the carbon is poured into the column (10 mm. diameter) and washed with 15 ml. water saturated with hydrogen sulphide. The mixture to be separated (20–30 mgm.) in 5 ml. of 5 per cent acetic acid saturated with hydrogen sulphide is filtered on the column, which is then washed with 25 ml. of 5 per cent acetic acid saturated with hydrogen sulphide. Non-adsorbed substances are thus washed into the filtrate. The aromatic peptides are eluted with 125 ml. of water saturated with ethyl acetate and hydrogen sulphide.

By the methods described above a complex mixture of neutral amino-acids and peptides, such as may result from partial hydrolysis of a protein, can be separated into different groups as shown in the following scheme:

Adsorption of Acid Peptides on Acid Alumina

Preliminary experiments with glutathione and glycyl-glutamic acid show that acid peptides are quantitatively adsorbed on acid alumina, like glutamic and aspartic acid; elution can be obtained either by acid or, better, by alkali.

All these experiments were done with synthetic di- and tri-peptides; there are reasons to believe that the same methods will be applicable to higher peptides.

Acknowledgments are due to Prof. Cl. Fromageot for his interest in this work, to Dr. H. Pénau (UCLAF, Paris) for a research fellowship granted to one of us (M. J.), and to Prof. V. Prelog (Zurich), Dr. M. Guggenheim (Basle), and Dr. C. J. Cavallito (Rensselaer, New York), for various synthetic peptides.

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THE TEACHING OF TAXONOMY

A JOINT meeting of the Linnean Society and the Systematics Association was held in the rooms of the former at Burlington House on February 6, when "The Teaching of Taxonomy" was the subject discussed. Sir Clive Forster-Cooper opened the discussion by noting the wide points of view and urging the importance of modern taxonomy. At one time taxonomy was the foremost branch of biology. It then suffered a decline relative to newer aspects and for a long time was considered a blind alley; but a revival of interest is now occurring. There are dangers in speaking too much of the 'professional' taxonomist, but the museum taxonomist is certainly overburdened in the answering of questions for others and has very little time left for research. It becomes a question whether all the wealth of facts and ideas now tending to be incorporated in taxonomy can be brought together in a unified syllabus for teaching in schools and universities. Sir Clive made the suggestion that the Systematics Association should appoint a committee to draw up some sort of guiding rules, of a sufficiently elastic nature, for the benefit of teachers, and to encourage them to teach students taxonomy along desirable lines.

Prof. James Gray considered it would be a pity if taxonomists should look upon their subject as a Cinderella, for though taxonomy is not the sole basis of biology it can play its part like all other branches in the development of the subject. Taxonomy must be seen as one of many points of view. Not more than 10 per cent of students of biology become taxonomists, and the problem for the teacher is how he can convey the taxonomic point of view and the discipline of the subject to the other 90 per cent so that they can carry away something which is to them a matter of intellectual pride. The systematist is to a large degree born such, and works much by general impressions. On the whole, the botanist seems to be more fortunate than the zoologist in having workable keys provided for him, and there is a great need in zoology for simple keys that can be used by students and teachers.

Dr. W. B. Turrill urged that plant taxonomy should be taught because it is indispensable to the proper study of every other branch of botany,

provides admirable material for training in observation, concentration, and record keeping; it is the best means by which students can become familiar with the great wealth of form and the extent of combinations and permutations of characters. Much of the time of professional taxonomists would be saved if more botanists were able to carry out a fair proportion of their own determinations and knew when, and when not, to call in the specialist. That taxonomy is not kept to the forefront in schools and colleges may be because it is a subject in which the teacher can be too easily caught out by his students. Dr. Turrill argued that the best way of giving instruction in taxonomy is by practice with material collected by the student himself. Actual practice in the use and making of keys, descriptions, and illustrations has the double advantage of establishing and increasing interest and in laying a solid foundation for discussion on the principles of classification. When the student is acquainted with sufficient factual data he should be helped to grasp the total of underlying principles and generalizations, and aided in giving them logical form. Through the whole of their course students should be made to go out into the field and garden to collect, handle, dissect, and record their findings for actual specimens which they must learn to classify and dissect. In brief, there are decided limits to the possibilities of the direct adequate teaching of taxonomy, but the student can and should be taught to teach himself taxonomy.

Prof. A. R. Clapham pointed out that plant taxonomy is a branch of botany in its own right and is also a tool for other branches. Yet botany has a unity imposed by its materials. The teacher has to aim at training botanists, and all his students should know something of the methods and principles of taxonomy just as those who become taxonomists should know at least a minimum of facts and principles in other branches. Taxonomy is not every man's meat. There must be the right mental outlook and a good appreciation of formal characters and of resemblances and differences, that is, a good visual memory. At the University of Sheffield, Prof. Clapham has no course planned solely for taxonomy, but the subject is united with other subjects such as floral biology, cytogenetics, or ecology. Emphasis is placed on the study of species, and examples are taken from the British flora. Small problems are set which may involve taxonomic studies. Taxonomy as a working tool is taught in the field by the study of quadrats and transects. Every year there are one or two students who are much more competent in taxonomy than are other students. These are encouraged to concentrate on the subject. The highest standards are insisted upon.

Prof. H. Boschma (University of Leyden) was introduced by Prof. de Beer as holding the unique position of professor of taxonomic zoology. Prof. Boschma replied to Prof. Gray that the latter's suggestion that identification of plants is easier than that of animals is not true for all groups in either kingdom. He gave some interesting details of the courses in zoology in Leyden. There are two main examinations. In preparation for the first, systematics is taught in association with anatomy; but for the second examination a special subject is chosen, and only a small percentage of students take systematic zoology. The special student is given material on which to work, is introduced to relevant literature, and then has very largely to investigate for himself. The successful students are the born systematists, and sufficient are selected to fill the vacant posts in museums and other institutions needing specialist taxonomists.

Dr. P. Richards thought that the reputation of taxonomy as a dull subject is due partly to an attempt to teach the results of taxonomy rather than taxonomy as a living branch of research, and partly to academic teaching being too much concerned with the families and larger taxonomic units rather than with species and intra-specific units. The characters of, for example, a family are extremely abstract. He described an experiment tried recently at Cambridge in which every advanced student makes, with some help and guidance, a thorough study of the taxonomy of a single variable species or of two or three closely related species, in the field, the laboratory, and the herbarium. The results have shown that the method is very successful in stimulating interest and in giving insight into the real nature of taxonomy. Dr. Richards also suggested that the teaching of taxonomic botany should not be based entirely on the flowering plants. In particular, mosses and liverworts provide excellent material, available at any time of the year, for the teaching of taxonomy. He also urged the need for a text-book of plant taxonomy covering the whole field. He suggested that the Systematics Association should initiate or encourage the writing of such a book.

Prof. A. E. Trueman referred to the point of view of the palæontologist and to the great difficulties of identification owing to the very great wealth of past life now known. More and more species and genera are having to be accepted. Whether it be studied for applied purposes or as part of the philosophy of biology, all kinds of taxonomic research and training are involved in palæontology.

Prof. A. G. Tansley agreed that a systematist must be born and endowed with a good visual memory. He stressed the importance of students working at individual species rather than being given abstract accounts of families. A student cannot build up a sound taxonomic knowledge unless he gets to know species in the field and herbarium.

Dr. S. P. Wiltshire stressed the need in plant pathology for training in the procedure of identification of fungi. The correct identification of pathogenic fungi is essential in order to make the relevant literature available. Yet many supposedly fully trained mycologists from the universities have never seen the inside of a herbarium packet or looked at the rules of nomenclature.

Mr. A. J. Wilmott said that by the study of one particular example of name change, if sufficiently complicated, all sorts of methods and bases of systematic work can be understood.

Dr. G. S. Carter considered that biology is now part of the schoolboy's *work* and has, therefore, less interest for him. Students should be encouraged to take up the problems of classification of small groups. This would make them realize what a species is.

Prof. I. Manton pointed out that many provincial teaching institutions have no great national collection of plants near at hand. She suggested that the Systematics Association might well arrange a course for precise training in herbarium methods.

Dr. O. W. Richards asked that universities should employ entomologists on their staffs and have entomology recognized as a degree subject.

The president of the Linnean Society, Prof. G. R. de Beer, in summing up the results of the discussion,

gave examples of the high cost of a lack of knowledge of taxonomy. It had been clearly shown that there is a wide recognition of the value of taxonomy and that more of it is wanted. When the Linnean Society was founded, taxonomy was the most prominent aspect of biology, and ever since, symposia on taxonomic subjects have been a recurring feature of its meetings. This shows the perennial value of taxonomy as an intellectual discipline. The Society itself is the custodian of important taxonomic collections, and the Council is fully prepared to co-operate in the giving of instruction in taxonomic principles.

FORTHCOMING EVENTS

Wednesday, April 9

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Dr. H. Steiner: "Aromatics from Petroleum".

Thursday, April 10

INSTITUTION OF CHEMICAL ENGINEERS (at the Connaught Rooms, Great Queen Street, London, W.C.2), at 11 a.m.—Twenty-fifth Annual Meeting; at 12 noon—Mr. Hugh Griffiths: "Crystallisation".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. C. T. Melling: "Commercial Development of Electricity Supply as a Consumer Service".

ILLUMINATING ENGINEERING SOCIETY, MANCHESTER CENTRE (in the Reynolds Hall, College of Technology, Manchester), at 6 p.m.—Mr. W. J. Wellwood Ferguson: "Lighting in Coal Mines".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. C. E. Fielding: "A Review of Production Difficulties in Relation to Aircraft Design".

WOMEN'S ENGINEERING SOCIETY, MANCHESTER BRANCH (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Dr. N. H. Searby: "Television".

Wednesday, April 9—Thursday, April 10

FARADAY SOCIETY (in the Chemistry Department, The University, Manchester).—General Discussion on "Electrode Processes".

Wednesday, April 9

At 10 a.m.—General Discussion.

Thursday, April 10

At 10 a.m.—General Discussion.

INSTITUTION OF ELECTRONICS, N.W. ENGLAND SECTION (in the Great Hall, College of Technology, Manchester).—Annual General Meeting and Second Annual Exhibition.

Wednesday, April 9, at 6.30 p.m.

Thursday, April 10, at 2.30 p.m.

MATHEMATICAL ASSOCIATION (at the Polytechnic, 309 Regent Street, London, W.1).—Annual General Meeting.

Wednesday, April 9—Saturday, April 12

PHYSICAL SOCIETY (at Imperial College, Imperial Institute Road, London, S.W.7), at 10 a.m.—Thirty-first Exhibition of Scientific Instruments and Apparatus.

Thursday, April 10—Tuesday, April 15

BRITISH PSYCHOLOGICAL SOCIETY (at the Bergman Österberg Physical Training College, Dartford Heath, Kent).—Annual General Meeting.

Mr. R. J. Bartlett: "Mind" (Presidential Address), at 5 p.m. on April 12.

Friday, April 11

TEXTILE INSTITUTE—(at 16 St. Mary's Parsonage, Manchester), at 1 p.m.—Mr. C. Garrett: "The Bleaching and Subsequent Dyeing of Jute Fabrics".

BIOCHEMICAL SOCIETY (at the Rowett Research Institute, Bucksburn, Aberdeen), at 2.30 p.m.—Scientific Papers and Demonstrations.

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

OIL AND COLOUR CHEMISTS' ASSOCIATION, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Annual General Meeting.

PAPER MAKERS' ASSOCIATION, NORTHERN DIVISION (at the Engineers' Club, Albert Square, Manchester), at 7 p.m.—Discussion on "From Press to Reel End".

SHEFFIELD METALLURGICAL ASSOCIATION, MODERN METHODS OF ANALYSIS GROUP (at 198 West Street, Sheffield), at 7 p.m.—Mr. G. Robinson: "Metallurgical Chromatography".

SOCIETY OF DYERS AND COLOURISTS (at St. Enoch Hotel, Glasgow), at 7 p.m.—Dr. G. L. Royer: "The Application of Microscopy to the Textile Field".

Saturday, April 12

BRITISH INTERPLANETARY SOCIETY (at the Science Museum, Exhibition Road, London, S.W.7), at 6 p.m.—Mr. Lionel Gilbert: "Cosmic Rays".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LABORATORY STEWARD (Grade D) IN THE DEPARTMENT OF BOTANY—The Professor of Botany, The University, Leeds 2 (April 8).

SCIENTIFIC OFFICER as ASSISTANT IN THE OPERATIONAL RESEARCH SECTION (University degree in Chemistry, Biology, Physics or Mathematics essential)—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Operational Research Section' (April 12).

DIRECTOR OF THE SCIENCE DEPARTMENT—The Director, Appointments Department, British Council, 3 Hanover Street, London, W.1 (April 15).

SENIOR LECTURER, and a LECTURER, IN THE DEPARTMENT OF ANATOMY—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (April 15).

LECTURER IN THE DEPARTMENT OF GEOLOGY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (April 24).

LECTURER with qualifications in Pure Mathematics, a LECTURER with qualifications in Applied Mathematics, and an ASSISTANT LECTURER with qualifications in Pure or Applied Mathematics—The Registrar, The University, Manchester 13 (April 24).

LECTURER (Grade III) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING (Electrotechnics)—The Registrar, The University, Liverpool (April 26).

CHIEF PHARMACIST to the Ministry of Health—The Director of Establishments, Ministry of Health, Whitehall, London, S.W.1 (April 26).

I.C.I. RESEARCH FELLOWSHIPS (3) IN CHEMISTRY or PHYSICS, or some allied subject such as Biochemistry, Colloid Science, Chemotherapy, Pharmacology, Metallurgy or Engineering—The Registrar, The University, Liverpool (April 30).

PROFESSOR OF PATHOLOGY in the Medical School, Dundee, and PATHOLOGIST and CLINICAL PATHOLOGIST to the Dundee Royal Infirmary (associated appointments)—The Secretary, The University, St. Andrews (April 30).

LECTURER IN MATHEMATICS, and a LECTURER IN MATHEMATICAL PHYSICS—The Secretary, Queen's University, Belfast (May 1).

TECHNICIAN in the Dental Hospital of the University of Bristol—The Professor of Pathology, Canynge Hall, Bristol 8 (May 1).

LECTURER IN SOCIAL PSYCHOLOGY—The Registrar, The University, Leeds 2 (May 1).

PROFESSOR OF METALLURGY—The Registrar, University College, Singleton Park, Swansea (May 3).

READERSHIP IN PURE MATHEMATICS tenable at King's College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 13).

LECTURER IN HUMAN PHYSIOLOGY—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (May 15).

METALLURGIST with industrial or research experience of foundry work, a METALLURGIST for independent research work on non-ferrous metal foundry problems, and METALLURGISTS (2) for the Liaison and Technical Service Department—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

LABORATORY STEWARD (biology)—The Head of the Department of Chemistry and Biology, The Polytechnic, 309 Regent Street, London, W.1.

ASSISTANT TECHNICAL SECRETARY IN THE METALLURGY DIVISION—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1 (endorsed 'Metallurgy Division').

ASSISTANT BIOCHEMIST at the Courtauld Institute—The Medical School Secretary, Middlesex Hospital, London, W.1.

LECTURER IN GEOGRAPHY, a LECTURER IN PURE MATHEMATICS, a LECTURER IN ORGANIC CHEMISTRY, a LECTURER IN PHYSICS, and an ASSISTANT LECTURER IN CHEMISTRY—The Registrar, University College, Leicester.

TECHNICAL RESEARCH ASSISTANT (well qualified) for nutritional research—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

SENIOR LECTURER IN MATHEMATICS—The Secretary, Royal Technical College, Glasgow.

RESEARCH CHEMIST—The Director of Research, Research Association of British Flour Millers, Cereals Research Station, Old London Road, St. Albans.

TECHNICAL INDEXER on the staff of the Plant and Animal Products Department—The Establishment Officer, Imperial Institute, South Kensington, London, S.W.7.

PHYSICIST with considerable knowledge of rubber technology, for research and development on the engineering applications of rubber, a PHYSICIST to work on fundamental aspects of rubber elasticity, a PHYSICAL CHEMIST to work on the kinetics of oxidation, and an ORGANIC CHEMIST to study the effect of structure on chemical reactivity—The Secretary, British Rubber Producers' Research Association, 19 Fenchurch Street, London, E.C.3.

CHEMIST, a BOTANIST, and an AGRICULTURIST, in the Intelligence Section of the Plant and Animal Products Department—The Establishment Officer, Imperial Institute, South Kensington, London, S.W.7.

CHEMIST or BIOCHEMIST to assist in isolation of substances of biological interest from natural sources—The Professor of Pathology, Sir William Dunn School of Pathology, Oxford.

ANATOMY DISSECTING-ROOM ATTENDANT, and a LABORATORY STEWARD (experienced) with knowledge of physics and laboratory administration—The Secretary, King's College, Strand, London, W.C.2.

METEOROLOGICAL OFFICERS IN MALAYA—The Director of Recruitment, Colonial Service, 15 Victoria Street, London, S.W.1.

LABORATORY TECHNICIAN—The Medical Superintendent, St. Luke's Hospital, Middlesbrough.